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NEW YORK UNDERGROUND RAPID TRANSIT railway matters have reached a more settled condition since our last issue was published. Under the arrangement agreed to by the Rapid Transit Commission, respecting the securities required of the successful contractor, Mr. John B. McDonald, August Belmont & Co., proposes: To organize a corporation with a capital of $6,000,000; to secure deposit of 20% of this capital on organization, 20% on May 1, 20% on Nov. 1, and the balance as called; to enter into contract with Mr. McDonald to promote the construction of the tunnel road; to accept the proposal of the board to secure from the Appellate Division a modification of the requirements by striking out the provision requiring construction sureties to qualify in double the amount of liability, and by reducing the minimum amount to be taken by each surety from $500,000 to $250,000; to arrange that Mr. McDonald is to furnish the $1,000,000 continuing bond with sureties who will justify in double that amount; to await the passage of an act of the legislature amending the rapid transit act by permitting the deposit of securities satisfactory to the board and of the value of $1,000,000 in lieu of the continuing bond; to execute as surety Mr. McDonald's bond to secure the performance of the contract for construction to the amount of $4,000,000, which will be accepted by the board; to cause the $1,000,000 cash required by the contract to be deposited with the Comptroller; and, as additional security to the city, to cause the beneficial interest in the bonds to be required of sub-contractors to be assigned to the city so far as may be necessary. Summarized, therefore, the city will have in hand at once in cash and securities for the execution of the contract $8,000,000 instead of the $7,000,000 required under the call for bids. This is made up as followe:

Bond from McDonald	$1,000,000
Bond from company	4,000,000
Bond from surety companies	1,000,000
Cash from company	1,000,000
Cash from company	1,000,000

We are informed by Mr. McDonald that matters will be in such condition that he will be ready to confer some time next week with persons who may wish to make subcontracts for doing portions of the work.

THE WASHINGTON CITY GRADE CROSSING REport, made to the U. S. Senate by the Commissioners, relates especially to the crossings of the Pennsylvania R. R. system. The report minutely details existing conditions and then proposes to eliminate grade crossings within the city limits by closing certain crossings, carrying other streets over the railway by bridges or by viaducts, and by changing the line of streets in some cases. It also proposes to enlarge the present passenger terminal of the Baltimore & Potomac Ry. by adding 190 ft. of the adjoining park, and to reconstruct the Long Bridge, and add a separate bridge over the Potomac for vehicles and pedestrians. The division of cost is as follows: Certain streets are to be cleared of tracks and repaved at the cost of the railway, and the railway is to pay for certain bridges viaducts and retaining walls. The United States and the District of Columbia will pay in equal parts for the cost of approaches when streets are carried over the railway, and all damages resulting from change of grade. The total cost to the government, exclusive of that of the Long Bridge, which belongs to the War Department, is estimated at $1,322,000. It is believed that the grade crossing bill prepared on this basis will meet with approval by all parties concerned.

THE FRAUDS IN THE SAVANNAH HARBOR contracts, for which ex-Capt. Oberlin M. Carter was courtmartialed and convicted, are again the subject of judicial inquiry. In December last a United States Grand Jury, in Savannah, found indictments against John F., Edward H. and Wm. T. Gaynor, B. D. Greene, and M. A. Connolly for conspiring with Carter to defraud the United States. They were arrested in New York, and for nearly two months proceedings have been in progress before a U. S. Commissioner as to whether they should be held for trial. The counsel for the indicted men, Mr. A. J. Rose, who is also attorney for Carter, has employed every legal artifice and technicality in behalf of his clients. A decision was rendered on Feb. 10, however, by U. S. Commissioner Shields to the effect that sufficient cause had been shown for holding the indicted men and a warrant has been asked for their removal to the Georgia district. It is of interest to note, as showing the length to which the counsel for the accused went in his plea for his clients, that Mr. Rose declared in the proceedings before the Commissioner that as soon as the project suggested by Capt. Carter for the Savannah Harbor contract was approved by his superiors, the Secretary of War or Congress, all his power, duty and discretion ceased, and he could not therefore be held responsible. Apparently this original view of the responsibilities of an engineer did not favorably impress the court.

THE APPEAL OF CAPT. CARTER from his sentence of imprisonment on habeas corpus proceedings was denied by Judge Lacombe some time ago, and the denial was approved by Judges Wallace and Shipman, of the Court of Appeals, on Jan. 25. As a last resort his counsel appealed to the U. S. Supreme Court and this appeal is still pending. The ground on which Carter's attorneys are endeavoring to secure his release is the technical one that the court martial could not legally inflict more than one punishment, and that the fine, the dismissal from the army in disgrace and the imprisonment were separate punishments.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear end collision on the Chicago & Northwestern Ry., at Ford River switch, near Escanaba, Mich., on Feb. 8, 1900. The collision occurred between a fast freight train and an accommodation train and the wreckage caught fire and burned. Ten persons were killed.—A head-on collision between two fast freight trains on the Beech Creek R. R., on Feb. 8, resulted in the death of three persons and the serious injury of three others.

FLOODS IN NEW ENGLAND, resulting from the heavy rainfall of Feb. 13 and the few preceding days, have caused considerable damage to highway and railway bridges, and to property and structures located along the Merrimac and Connecticut Rivers and their tributaries. Several dams, including those at Quinapoxset, Eagle and Harris Mills in Massachusetts, have been swept away and at the last accounts the temporary dam of the Metropolitan Water Board at Clinton, Mass., was seriously threatened with destruction. It is stated that the Connecticut River rose 5 ft. during the day, Feb. 13, with the prospect of still higher water to follow. Other New England streams show proportionate increases.

AMERICAN SHIPBUILDING is reported upon by Mr. E. T. Chamberlain, Commissioner of Navigation, as to the vessels now under construction for commerce and war. The total is 109 vessels of an aggregate of 327,571 tons. Divided by yards, and into merchant and warships, the report can be condensed as follows:

Yard of builder.	No. vessels.	Merchant, tons.	No. vessels.	War, tons.
Newport News Shipb'lding Co.	8	52,600	5	50,000
Wm. Cramp & Sons Co.....	10	66,000	2	23,865
T.S.Marvel Co.,Newburgh,N.Y.	5	3,550	..	.....
Neafie & Levy, Philadelphia..	7	6,428	4	4,460
Harlan & Hollingsworth, Del..	8	10,625	3	1,156
Burlee Dry-Dock Co.*.....	9	4,560	..	.....
Maryland Steel Co., Baltimore	4	14,800	3	1,299
Bath (Me.) Iron Works.....	2	1,050	5	6,936
Union Iron Wks,San Francisco	..	8,500	7	31,700
Columbian Iron Wks,Baltimore	2	1,904	2	333
Del. River Ship Co., Chester..	4	19,400	..	.....
Wm.R.Trigg Co.,Richmond,Va.	..	.....	6	4,535
Wolf & Zwicker, Portland,Ore.	..	1,600	1	247
Gas Engine & Power Co., N. Y.	..	.....	3	820
Crescent Shipbuilding Co.†...	..	.....	4	6,783
G. Lawley & Son Co., S.Boston	..	.....	2	339
Fore River Engine Co.,‡.....	..	.....	3	4,000
Total	59	191,107	50	136,464

*Port Richmond, Long Island, N. Y. †Elizabeth, N. J. ‡Weymouth, Mass.

THE "GATES" LAKE FREIGHTER, lately launched at the Lorain shipyard, of Cleveland, O., is one of four now being built for the American Steel & Wire Co., or the American Steamship Co., as the controlled company is called. The "Gates," says the "Marine Review," is 478 ft. long on the keel, and nearly 500 ft. long over all; the molded beam is 52 ft., depth 30 ft. Steel is used throughout, for hull, masts, deck houses, etc., and the hull is divided into 13 watertight compartments, with a water ballast capacity of 3,500 tons. On each side of the center line of the hull are five longitudinal girders, and the between deck 15-in. heavy channel beams, spaced 8 ft. apart for the length of the cargo holds, are attached to 15-in. channel bent-frames, similarly spaced. Stringers and longitudinal girders tie and braces the beams and frames strongly together. The 15 cargo hatches are 30 by 8 ft. in the clear and spaced 24 ft. apart on centers. The engine used will be of the quadruple expansion type, with 16½, 25½, 38½ and 60-in. cylinders and 40-in. stroke. The propeller is 14 ft. diameter and 15½ ft. pitch. Steam will be supplied by Babcock & Wilcox water-tube boilers, having 140 sq. ft. of grate surface, 6,800 sq. ft. of heating surface and working to 250 lbs. pressure; the coal bunkers carry 300 tons.

THE VALUE OF THE CARNEGIE STEEL PLANT may soon be discussed in the courts under a rumored suit to be brought against Andrew Carnegie by H. C. Frick, one of his partners. In July, 1892, when the present company was organized, Mr. Carnegie held $15,883,333 out of the $25,000,000 stock capital; Mr. Frick held $2,500,000, which he has since increased to $8,000,000. Mr. Frick is supposed to have had an option for the purchase of the Carnegie interest at $100,000,000, but this option was not extended, and Mr. Carnegie is now reported to demand five times as much as he formerly did for his interest. Mr. Frick would sell out on the basis of Mr. Carnegie's valuation; but the latter now proposes to close on the valuation of a number of years ago. Hence the rumored suit for an accounting and settlement of interests on book values. It is also rumored that Mr. Frick is negotiating with the Pennsylvania Steel Co. for the Sparrow Point plant of the Maryland Steel Co. The gross earnings of the Carnegie Steel Co., for 1899, are reported as having been somewhere between $40,000,000 and $42,000,000, while the net earnings were $21,000,000.

A LABOR STRIKE of more than ordinary importance is now in progress in Chicago, and about 3,000 men quit work during the first two days. It includes bricklayers, masons, structural iron workers, stone cutters, carpenters, gas fitters, steam fitters, and building laborers. Some weeks ago we referred to the arbitrary action taken by the labor organizations in regard to hours, wages, limitations of work, prohibition of machinery, etc. As a result of this a large number of the leading building contractors have formed an organization to resist the demands of the labor organizations, and they declare their intention of employing non-union labor and carrying on their business as they see fit. In some of the stone cutting yards, the employers have started up machinery which has been idle for two years, under the prohibition of the labor unions.

WATER STORAGE TANKS UNDER AIR PRESSURE have just been installed as a part of the new water-works system at Lacona, N. Y. There are two air chambers and two water chambers, giving a water storage of 12,000 gallons. An engine and air compressor maintains a pressure of 50 lbs., ordinarily, which may be increased to 100 lbs. The system, as used at Babylon, N. Y., and Southampton, N. Y., was described in our issue of Dec. 30, 1897. It is covered by U. S. Patent No. 578,505, issued to the late Wm. E. Worthen, and Oscar Darling, and now owned by the Acme Water Storage & Construction Co., of New York city.

THE PRICE OF GAS AT HAVERHILL, MASS., will probably be reduced to 80 cts. per 1,000 cu. ft. in accordance with a recommendation of the Massachusetts Gas and Electric Light Commissioners. This action was taken after a hearing on a petition submitted in behalf of the city. There is some talk of an appeal to the courts by the company, but the well-known conservatism of the board renders a reversal of its decision unlikely.

THE PACIFIC CABLE BILLS are being sharply discussed in the House Committee on Interstate and Foreign Commerce. The vote will be close between granting a subsidy and government construction. The Sherman bill, as changed, increases the subsidy from $100,000 to $400,000 per year, and limits the free transmission of government messages to 20 years, and provides thereafter for half rates, estimated at another $400,000 per year. The Corliss bill provides for government construction under the joint supervision of the Postmaster-General and Secretaries of War and the Navy. Capt. G. O. Squier, assistant to Gen. Greely, estimates the cost of the cable at $10,000,000, requiring total net earnings of $925,000 per year to meet expenses. He denies the claim of the Eastern Extension Cable Co., owning the Manila-Hong Kong cable, to a monopoly under Spanish contracts. The argument in favor of government construction is that all the nations of the earth are owning cables, and Great Britain paid $60,000,000 at one time to acquire some cable lines, and the Admiralty claims that this purchase has doubled the value of the navy by keeping it in close touch with the government. The subsidy act is objected to because it gives special privileges and a bounty at the same time, and will be a monopoly for many years by reason of its great cost.

TESTS OF SMALL, MODEL, CEMENT ARCHES TO DETERMINE THE VALUE OF TIE RODS.

By Daniel B. Luten.*

The increasing use of concrete in the construction of arch bridges, and the necessity for invariability of span and security of abutments in such structures, led to the designing by the writer of an arch bridge having timber ties from one abutment to the other beneath the bed of the stream to sustain the horizontal thrust of the arch. The device is of course best suited to low, flat arches of moderate span. Its advantages are: increased stability of abutments, permitting lighter construction; less danger from scouring of the bed of the stream;

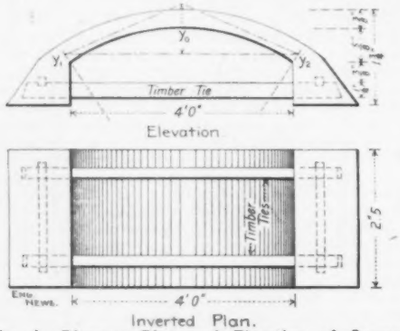


Fig. 1.—Diagram Plan and Elevation of Cement Arch Model Tested to Determine Value of Tie Rods.

and uniform distribution of pressure on the foundation. In such an arch, no reliance need be placed upon doubtful pressure from earth backing, and the weight of the abutments is of slight importance in resisting the horizontal thrust. The pressure of the abutments upon the base is, therefore, vertical, producing uniform distribution of stress. Timber beneath the water line is practically permanent, insuring the durability of the structure.

A series of tests was made upon small cement models of such an arch, which, while they may not be safe guides in proportioning a large structure, are, nevertheless, of some interest in showing the strength that such a combination of cement and timbers may develop. The models were made of neat Portland cement, of dimensions as shown in Fig. 1, span 4 ins., rise ⅝-in., thickness at crown ⅜-in., and length 2½ ins. The form of arch ring was segmental circular, of arc 70°, and radius 3⅝ ins. Two timbers, each ¼-in. square in cross-section, were embedded in the cement so as to tie the two abutments together, and were secured by interlocking cross timbers. These ties were ⅝-in. below the springing line of the arch. The cement, after molding, was kept in moist air for 24 hours, and then immersed in water for six days. The models were then placed on supports, so that only the abutments and timber ties were under water.

Fig. 2 represents a comparative test of two of the arches, one with timbers intact, the other with the timbers cut so as to be useless. The former was eight days old and the latter ten days old. The models were placed upon a bed of wet sand 1 in. in depth, purposely to lessen the horizontal reaction of the abutments. Loads were applied by means of cast-iron weights of 10 lbs. each, the load being concentrated at the middle of the span. Fig. 2 shows the total load applied just before failure occurred; 110 lbs. was the greatest load carried by the arch with timber ties, and 30 lbs. the greatest carried by the other. The photograph of the maximum load was obtained by repeating the exposure upon the same sensitive plate for each load applied, with the camera in a fixed position. After the weaker arch had failed, it was covered with a black cloth and the loading and photographing of the other continued until failure.

The arch, with the timbers cut, failed by fracture at the middle, since it was acting simply as a beam. After failure the two halves were replaced in their original position and again loaded in order to determine how much of the load was supported by horizontal thrust at the abutments. The arch fell under a weight of 1 lb. showing that the horizontal thrust was insignificant. The method of failure of the other arch is shown in Fig. 3. It began to fail at 90 lbs. by the pulling out of the timbers from the left-hand abutment; at 110 lbs. a crack appeared at the crown, and as the abutments spread farther apart the crown slowly crushed down to the position shown in the illustration, Fig. 3. Fig. 4 shows the arches after destruction; and also shows the size of the cast-iron weights used in the loading.

This test was repeated on another pair of arches, the one with timber ties being ten days old and the one without, eight days old; the former fell under 160 lbs., failure being due to the sudden rupture of the timbers near the abutment; the latter arch broke down under a load of 30 lbs.

A further test was made to find the effect of distributed loads, and abutments backed by earth filling. The two arches of Fig. 5 were bedded on ½-in. of sand, and wet sand was tamped against the abutments, and carried over the haunches to distribute the load.

The cast-iron weights were then applied, care being taken to keep the sand cleared away from over the abutments, so that the arch ring would be compelled to carry the entire load. The arch without timbers fell at 40 lbs. weight, cracking at the crown. The arch with timber ties carried 270 lbs., as shown in Fig. 5, without signs of weakening. At 300 lbs. the timbers began to pull out of the abutment on the left and at 310 lbs. the arch ring was crushed in, failing so slowly, however, that it was possible to photograph it, as shown by Fig. 6.

The increase of load in this case over the other arches tested, is not to be attributed entirely to the sand backing or to the distribution of the load, but rather to better construction of the model, the timbers apparently being better embedded in the cement. On the other arch the sand backing apparently added about one-third to the breaking load.

It cannot be assumed that the pressure due to the backing of the abutments of an arch on so small a scale would bear any relation to the pressure on a full-sized structure, and no general quantitative deductions can be drawn from such experiments. No analysis is possible with the arch of Fig. 5 on account of the uncertainty of the distribution of the load. The arch of Fig. 2 was analyzed by Greene's graphical method, as follows:

The three equations of condition to determine the equilibrium polygon for a segmental circular arch are:

$$(1.)\quad \text{Sin } \beta\ y_0 + \tfrac{1}{2}(\sin\beta + \sin\alpha)\ y_1 + \tfrac{1}{2}(\sin\beta - \sin\alpha)\ y_2 = (\beta - \sin\beta\cos\beta)\ r.$$

$$(2.)\quad -\sin\beta(\cos\alpha - \cos\beta + \alpha\sin\alpha - \beta\sin\beta)\ y_0 + \tfrac{1}{2}(\sin\beta - \sin\alpha)(\cos\alpha - \cos\beta + \alpha\sin\alpha - \beta\sin\alpha)\ y_1 + \tfrac{1}{2}(\sin\beta + \sin\alpha)(\cos\alpha - \cos\beta + \alpha\sin\alpha + \beta\sin\alpha)\ y_2 = (\sin\beta - \beta\cos\beta)(\sin^2\beta - \sin^2\alpha)\ r.$$

$$(3.)\quad [(\beta - \cos\beta\sin\beta)\sin\alpha - (\alpha + \sin\alpha\cos\alpha - 2\sin\alpha\cos\beta)\sin\beta]\ y_0 + \tfrac{1}{2}(\sin\beta - \sin\alpha)(\alpha + \sin\alpha\cos\alpha + \beta - \sin\beta\cos\beta - 2\sin\alpha\cos\beta)\ y_1 + \tfrac{1}{2}(\sin\beta + \sin\alpha)(\alpha + \sin\alpha\cos\alpha - \beta + \sin\beta\cos\beta - 2\sin\alpha\cos\beta)\ y_2 = 0.$$

In which β equals one-half the angle of the segment of the circle; α equals the angle between the crown and the load; r equals the radius of the circle, and y_0, y_1, and y_2 are the ordinates to the equilibrium polygon.

In this case β equals 34° 51′, α = 0° and r equals 3.62 ins.

Substituting these values, the equations become:

$$2\,y_0 + y_1 + y_2 = 1.785 \quad (1)$$

$$1.879\,y_0 + y_1 + y_2 = 1.676 \quad (2)$$

$$y_1 - y_2 = 0 \quad (3)$$

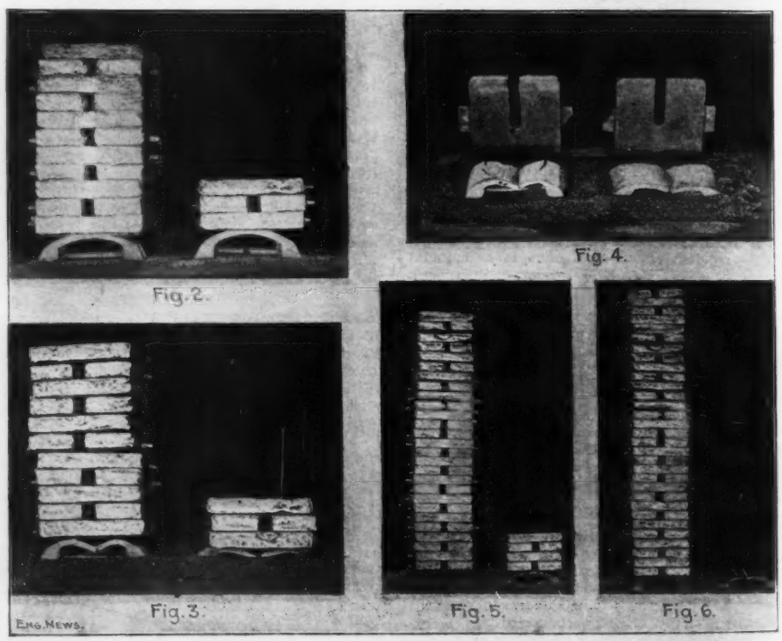
from which

$$y_0 = 0.9 \text{ ins.}$$

and $y_1 = y_2 = -0.008$ ins. The equilibrium polygon may now be drawn as shown in dash-dotted lines in Fig. 7.

Taking moments about the apex of the equilibrium polygon, the horizontal thrust of the arch under the load of 110 lbs. is found to be 120 lbs., which is approximately the stress in the timbers. The stresses in the cement at the crown where the greatest force occurs, are computed on the assumption that the stress varies uniformly as its distance from the neutral axis. The total compression is about 200 lbs., and the total tension about 80 lbs., giving maximum compression of about 700 lbs. per sq. in., and a maximum tension of about 375 lbs. per sq. in.

As the dimensions of the arch are increased, the load which will produce the same unit stresses in the material varies as the square of the ratio of increase. In an arch one hundred times as large, giving a span of 33 ft. and length of 20 ft., the load



FIGS. 2 TO 6.—VIEWS SHOWING COMPARATIVE BREAKING LOADS CARRIED BY CEMENT ARCH MODELS WITH AND WITHOUT TIE RODS.

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required to produce these same unit stresses would be $(100)^2 \times 110 = 550$ tons, and for an arch of the same span and 60-ft. roadway, a load of 1,650 tons concentrated on the crown would produce the same stresses. Such stresses are, of course, not allowable in concrete, although a tension of 60 lbs. per sq. in. may safely be allowed in good Portland cement concrete. On the other hand it is to be noted that this concentrated load produces an extreme case of tension, and that concrete has a much higher allowable stress in compression.

Since the load varies as the square of the dimensions of the arch, the same depth of cast-iron loaded similarly on the larger arch would produce the same stresses as in the smaller. For example, cast-iron plates 6 ins. square, and 11 ins. in depth was the limiting load on an arch of 4 ins. span and 2½ ins. in length. On an arch one hundred times as large or 33 ft. span and 20 ft. in length, the equivalent load would be a plate of cast-iron 50 ft. square and 11 ins. deep, equivalent to a cast iron block of $10 \times 12 \times 20$ ft.

THE DESIGNING OF SKEW CONNECTION DETAILS FOR ROOF AND BRIDGE WORK.†

By C. A. P. Turner, C. E.

(With two-page plate.)

I.

Skew details, such as are found in roof work, skew portals of bridges, etc., cause the inexperienced draftsman considerable worry and not infrequently more experienced men are puzzled by them to such an extent that double or quadruple a reasonable amount of time is spent in figuring them, and even then occasionally the work fails to go together satisfactorily. While in straight work there is reasonable excuse for error, as in figuring twice by the same method, the same mistake is quite likely to be made by the same man a second time, with skew details there are such a number of independent methods of figuring every step of the work; and the probability, where two independent methods are used, of two different mistakes balancing, is so remote that error is correspondingly inexcusable. As the methods applicable to roof work are strictly general, we will first confine our discusion to this and take up special connections later.

Skew Details in Roof Work.

In determining main dimensions, such as lengths of purlins, main jack and hip rafters, it is generally best to figure these distances in the same plane, and afterwards reduce them to the plane in which they are wanted. The plane in which the main dimensions are first figured, may be termed the reference plane, and should be so selected, that there will be the least possible work in reduction of the distances determined in it. Where a main dimension on the detail drawing is not given upon the line of the reference plane on which it was first figured, this line should preferably be shown on the detail drawing, in order that errors of reduction may be readily detected. All reference points should be located for the same reason. For example, where a piece is figured to the intersection of certain lines or planes and the bent plate connection is made short of this, the point or line of intersection should be given, and the distance from it to the line of bend, thus enabling the work to be checked at each step of its progress. Too much care cannot be exercised in getting the main dimensions correct, as upon them depends the whole value of the work. The surest and best way to determine them correctly, is to figure every dimension by two entirely independent methods, and then if the same result is obtained they are most probably correct.

The first step in taking hold of a complicated roof should be to make a plan, showing wall lines, chimneys, main hip and valley rafters and purlins, unless the latter are tees or angles, spaced from ten to twenty inches between centers, in which case, a special diagram should be made for them. Let Fig. 1 represent a part of such a diagram. Let slope a, make an angle A, with the horizontal. Let the angle between R, a main rafter, and H, the hip rafter, in the plane of roof, equal P_a for slope a, and P_b for slope b. Then, we may figure the lengths of the main pieces, by angles, having given the distances c, d, a, and b,

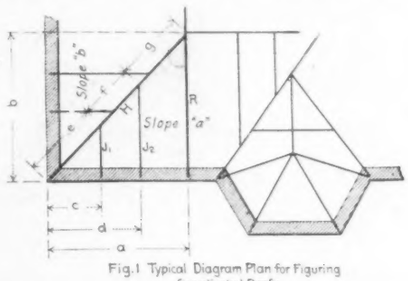

Fig.1 Typical Diagram Plan for Figuring Complicated Roofs.

through the angles A and P; or we may figure them by squares, or, having determined the lengths of R and H, by squares or angles, we may determine e, f, g, and the lengths of J1 and J2 by proportion, the latter method being generally shorter, when c and d are some even fractional part of a. Thus, we may determine the length of the hip H, by any of the following methods:

$H = \sqrt{a^2 + b^2 + (b \tan A)^2} = a \operatorname{cosec} P_a = b \operatorname{cosec} P_b = R \sec P_a = (\sqrt{a^2 + b^2}) \sec I$,

I being the angle of inclination of the hip with the horizontal. R the rafter length $= b \sec A = a \cot P_a = H \cos P_a = \sqrt{b^2 + (b \tan A)^2}$.

The following useful wrinkles in figuring may well be kept in mind:

In a roof slope of 5 ins. rise to 12 ins. run, the length of the rafter is the run, plus one-twelfth of run, since $\sqrt{12^2 + 5^2} = \sqrt{169} = 13$.

In a roof slope of 9 ins. rise to 12 ins. run, the length of the rafter equals one and a-quarter times the run.

In a slope of 4 ins. rise in 12 ins. run, the length of the rafter squared, equals ten times the square of the rise, or ten-ninths the square of the run.

In a 30° slope, the length of the rafter squared, equals four-thirds of the square of the run, and the rise equals half the rafter length, since sine 30° equals one-half.

For a slope of 6 ins. rise to 12 ins. run (¼ pitch), the length of the rafter squared equals five times the square of the rise, or five-fourths of the square of the run.

Bevel Angles.—Where two roof planes meet forming a hip or valley, the sets of bevel angles for connecting purlins to this hip or valley rafter are alike in the two roof planes only when they have the same inclination to the horizontal. In the latter case, the vertical plane through the center line of the hip or valley rafter, bisects the wall angle or the angle between the lines cut from a horizontal plane by the roof planes. (We will term this vertical plane passing through the center line of the hip or valley rafter; the plane of web of hip, and the plane normal to it and parallel to the center line of the hip rafter, the plane of back of hip, in the discussion to follow.)

In case the two roof planes have different inclinations, as is frequently the case, it is necessary, before trying to determine the bevel angles, to determine the angle in plan between the hip or valley and the wall or eave line; since, as will be shown later, the set of bevels for each roof plane are a function of its inclination to the horizontal, and the above angle, which may be more concisely defined as the angle between, (1), the line cut from the horizontal plane by the roof plane, and, (2), the line cut from a horizontal plane by the plane of web of hip or valley rafter.

Having given the slope angles a and b of the two respective roof planes with the horizontal, and the angle of intersection C, of the eave or wall lines; to find B, the angle between the hip in plan and the eave line for that slope, take any point (Fig. 2), at a height h above the horizontal plane e b f. Draw e d perpendicular to e b and f d perpendicular to b f.

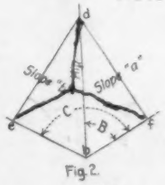

Fig.2.

Then

$$\left(\frac{h}{\tan a}\right) = \left(\frac{h}{\tan b}\right)$$

$$\cot B = \frac{\tan a + \cos C \tan b}{\tan b \quad \sin C},$$

$$= \operatorname{Cot} C + \frac{\tan a}{\tan b \sin C},$$

When $C = 90°$ and $a = b$,

$$\frac{\tan a + \cos C \tan b}{\tan b \sin C} = 1 \text{ or } B = 45 \text{ degrees.}$$

When slope a equals slope b,

$$\cot B = \frac{1 + \cos C}{\sin C} = \cot \frac{1}{2} C, \text{ or } B = \frac{1}{2} C.$$

When C = 90, and a and b are unequal,

$$\operatorname{Cot} B = \frac{\tan a}{\tan b},$$

In using the general equation for the value of Cot B, the sign of Cot C should not be overlooked. Thus, when C is greater than 90° and less than 180°, Cot C is negative, and Cot B equals the numerical difference between cot C and $\left(\frac{\tan a}{\tan b \sin C}\right)$.

Normal Purlins.—In discussing the bevel angles for normal purlin connections, we will use the following notation: Let A equal the angle between the plane of roof and a horizontal plane; B equal the angle between the lines cut from a horizontal plane by the plane of web of hip and the roof plane; I equal the angle made by the hip or valley rafter with a horizontal plane; P equal the angle in the plane of the roof between a main and a hip or valley rafter; X equal the angle between (1) the intersection line of the plane of web of a purlin with the plane of web of hip; and (2) a vertical line in the plane of web of hip; G equal the angle between the roof plane, and the plane of back of hip rafter; V equal the angle in the plane of web of purlin, between a normal to the center line of purlin, and the line cut from the plane of web of purlin, by the plane of web of hip; M equal the amount the angle between the plane of web of purlin, and the plane of web of hip, differs from 90°; D equal the angle between (1), the line cut from the plane of the back of the hip, by the plane of the web of purlin, and (2), a line normal to the plane of web of hip, and in the plane of back of hip; F equal the amount the angle between, (1), the line of intersection of the plane of web of purlin, with the plane of web of hip, and (2), the line of intersection of plane of web of purlin, with plane of back of hip; differs from 90°; Z equal the difference between the angles X and I.

Since all of these angles are functions of A and B, there are many interesting relations between them, which may be best illustrated by the derivation of a number of the more simple ones.

Taking the right-angled spherical triangle, (Fig. 3), formed by the intersection of the plane of web of hip, a horizontal plane, and the roof plane; with a sphere whose center is the point of intersection of the three planes, by Napier's rule; in any right-angled spherical triangle, the sine of a middle part equals the product of the cosines of the opposite extremes, we may write,

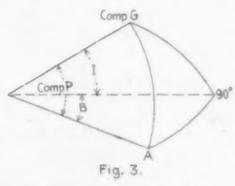

Fig. 3.

$\sin I = \cos P \sin A$;
$\sin B = \cos P \cos G$;
$\cos A = \cos I \cos G$;
$\sin G = \cos B \sin A$;
$\sin P = \cos I \cos B$.

Taking the equations above and substituting in the second members of each, the value of each factor as found in some of the others, we have:

$\sin I = \tan B \tan G$, or $\tan G = \sin I \cot B$;
$\sin B = \tan I \cot A$, or $\tan I = \tan A \sin B$;
$\cos A = \tan P \tan B$, or $\tan P = \cot B \cos A$;

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$\sin G = \tan P \tan I$, or $\tan P = \cot I \sin G$;
$\sin P = \cot A \tan G$, or $\tan G = \tan A \sin P$.

By substituting in the last set, the values of the sines and cosines as found in the first, we may get a series of equations of the following form, thus: Tan G equals tan A cos I cos B, etc., which are of little value when we are familiar with the simpler ones given.

Taking the spherical triangle formed by the intersection of a vertical plane through a rafter, the plane of web of hip, and the plane of web of purlin, with a sphere whose center is the point of intersection of the three planes, in like manner we find from Fig. 4:

$\sin A = \sin X \cos M$;
$\sin V = \sin X \cos B$;
$\sin M = \cos A \cos B$;
$\sin B = \cos V \cos M$;
$\cos X = \cos A \cos V$;

from which

$\tan V = \sin A \cot B$;
$\tan M = \sin V \cot A$;
$\tan V = \sin M \tan X$;
$\cot X = \cot A \sin B$;
$\tan M = \cot B \cos X$.

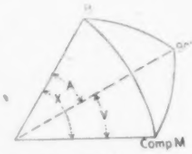


Fig. 4.

Now, from the spherical triangle formed by the intersection with a sphere, of the plane of back of hip, the plane of web of hip, and the plane of web of purlin; the center of the sphere being the point of intersection of the three planes, we have (Fig. 5):

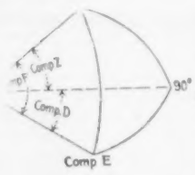


Fig. 5.

$\cos Z = \cos F \cos E$;
$\cos D = \cos F \cos M$;
$\sin E = \sin Z \cos M$;
$\sin M = \sin D \cos E$;
$\sin F = \sin D \sin Z$;

from which

$\tan D = \tan M \sec Z$;
$\tan E = \tan Z \cos D$;
$\tan F = \tan D \sin E$;
$\tan F = \tan Z \sin M$;
$\tan E = \cot M \sin F$.

The angle (V-F), is the angle in the plane of web of purlin, between the center line of purlin and the line cut from the web of purlin by the plane of back of hip, and may be determined by taking the difference of the angles V and F, as found by the previous equation; or it may be determined from its relations to other angles of the set.

In the accompanying Fig. 6 let abc be the roof plane; ebd be the plane of back of hip; aeb the plane of web of purlin; cbd a plane normal to the center lines of hip and the angles as noted.

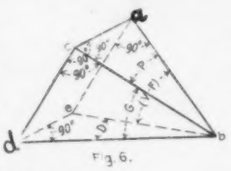


Fig. 6.

Then cd ÷ cb = tan G, and ae ÷ ab = tan (V-F); but ae = cd, and ab = cb ÷ cos P, therefore tan (V-F) = tan G cos P.

In like manner we may show sin (V-F) = sin G cos D.

Also, as will be shown later, tan Z = tan P, sin G = sin M tan V, and sin Z = sin P sin V.

By substituting the values of one set in the equations of another, various other relations may be established. Those of most value are those which are the simplest, which give the angle in terms of its tangent, and derive it directly from the angles A and B, or from I and P.

The writer would select the following equations as best filling these conditions, and which check themselves by figuring the two equal values given for tangents M and D, and noting that (V-F) has the same tangent as determined by (11):

(1) Tan I = tan A sin B.
(2) Tan P = cot B cos A.
(3) Tan V = sin A cot B.
(4) Tan G = sin I cot B.
(5) Cot X = cot A sin B.
(6) Z = X-I.
(7) Tan M = cot B cos X = tan P cos V.
(8) Tan D = tan P cos G = tan M sec Z.
(9) Tan E = tan Z cos D.
(10) Tan F = sin E tan D = tan Z sin M.
(11) Tan (V-F) = tan G cos P.

The functions of the angles A, B, I, and P should be accurately determined, as they are useful in figuring main dimensions, while all the others may be determined with sufficient accuracy with the common slide rule.

When B = 45°, little figuring is necessary, since equations 2, 3, 4 and 7 reduce to

(2a) tan P = cos A;
(3a) tan V = sin A;
(4a) tan G = sin I;
(7a) tan M = cos X.

When A = 45° for any value of B,
cot X = tan I = sin B, angle P = angle V;
tan G = tan M = sin P;

$$\tan Z = \frac{1}{2} \cos B \cot B = \frac{1}{2} (\text{cosec } B - \sin B).$$

When A = 45° and B = 45°, we have:
tan I = tan P = tan V = cot X = sin 45, or angles I, P, V and comp. X are equal.

Now $\sin G = \cos B \sin A = \cos B \cos A = \sin M = \frac{1}{2}$, therefore G = M = 30°; also

$$\tan Z = \sin G \tan P = \frac{1}{2} \cos 45° = .3535, \text{ and}$$

$$\sin Z = \sin P \sin V = \frac{1}{3};$$

$$\tan F = \tan Z \sin M = \frac{.3535}{2} = .1768;$$

$$\tan D = \frac{1}{2} \sec P;$$

$$\sin E = \frac{1}{3} \cos M;$$

so that for this case the angles are practically known.

Reference to sketches Fig. 7, showing hip and valley castings used for connecting slating angles to hip and valley rafters; and to details of purlin connections shown by Fig. 8, will give perhaps a clearer idea of these angles than would be generally obtained from the definitions given.

We have now derived formulas for the bevels most commonly met in roof work. Occosionally, however, jack rafters are framed on top of the hip or valley rafter, and in this case we have a new set of bevel angles.

Bevel Angles for Jack Rafter Connections to Back of Hip or Valley Rafters.—Use the previous notation and let, N = the angle between the center line of the jack rafter, and the line cut from the plane of back of hip by the plane of web of jack rafter; let K = the amount the angle, between the plane of back of hip and the plane of web of jack rafter, differs from 90°; let S = the angle measured in the plane of back of hip or valley rafter, between the center line of hip or valley, and the line cut from the back of hip or valley by the plane of web of jack rafter.

From the right-angled spherical triangle (Fig. 9) formed by the intersection of the plane of web of jack, and the plane of back of hip, and the roof plane with a sphere whose center is the point of intersection of the three planes, we may write:

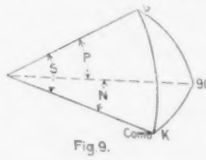


Fig. 9.

$\sin P = \sin S \cos K$;
$\sin N = \sin S \sin G$;
$\sin K = \cos P \sin G$;
$\cos G = \cos N \cos K$;
$\cos S = \cos P \cos N$;

from which

$\sin P = \cot G \tan N$;
$\sin N = \tan P \tan K$;
$\sin K = \cot S \tan N$;
$\cos G = \cot S \tan P$
$\cos S = \tan K \cot G$.

Again, taking the spherical triangle (Fig. 10) formed by the intersection of a horizontal plane, the plane of web of jack and the plane of back of hip, with a sphere whose center is the point of intersection of the three planes, we may write:

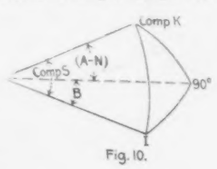


Fig. 10.

$\sin (A-N) = \cos S \sin I$;
$\sin B = \cos S \cos K$;
$\cos I = \cos (A-N) \cos K$;
$\sin S = \cos (A-N) \cos B$;
$\sin K = \cos B \sin I$;

from which

$\sin (A-N) = \tan B \tan K$;
$\sin B = \tan (A-N) \cot I$;
$\cos I = \tan S \tan B$;
$\sin K = \tan S \tan (A-N)$;
$\sin S = \cot I \tan K$.

For computation, the following equations are best:

$\tan (A-N) = \sin B \tan I$;
$\tan N = \tan G \sin P$;
$\tan s = \cot B \cos I$;
$\tan K = \sin S \tan I$;
$\sin K = \sin I \cos B$.

When A = 45° and B = 45°:

$$\tan (A-N) = \sin^2 45° = \frac{1}{2};$$

$$\tan N = \frac{1}{3};$$

$\tan S = \cos P$;
$\sin S = 2 \sin N$;
$\tan K = \sin (A-N)$;

$$\sin K = \frac{1}{2} \tan S = \frac{1}{2} \cos P.$$

When B = 45°, for any vale of A:
tan S = cos I;

$$\tan (A-N) = (\sin^2 B \tan A) = \frac{1}{2} \tan A.$$

A clear understanding of the relative values of the bevel angles to each other, will be of value in detecting errors in the work; sin K = sin (V-F) cos E, therefore K is always less than (V-F). Now tan S = cot B cos I, while tan P = cot B cos A, therefore, as I is always less than A, tan S is always greater than tan P, for any value of A other than zero or 90°. Fig. 11 will illustrate

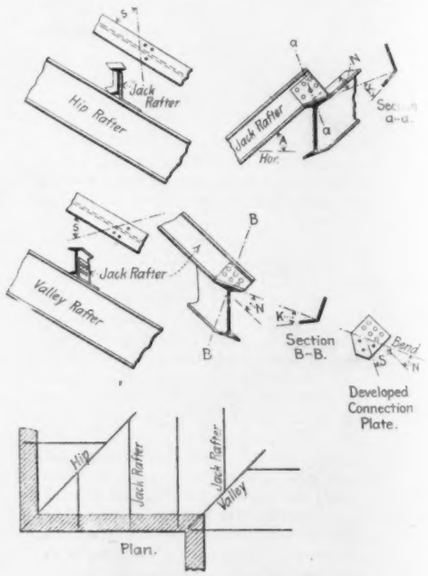


Fig. 11. Connections for Jack Rafters to Hip and Valley Rafters.

these bevel angles, in the connections of a jack rafter to either a hip or valley rafter. The angles I and (A-N), increase as B increases for a constant value of A, while all the other angles decrease. For A constant and B variable, tangents P and V vary as cot B, sines G and M as cos B, and tan Z as the product of cos B into cot B. For any value of B, P equals V for a slope of comp. A and G equals M for comp. A. Angles I, V, G, K and (V-F) increase as A increases, while P, M, D and S decrease as A increases.

For any value of B, Z is a maximum when A equals 45°, and decreases as A approaches zero or 90°. Where B is 60° or greater, the value of

sec Z is so near unity that we may take D as equal to M for practical purposes. The commonest case is where B = 45°. The diagram Fig. 12 is a bevel diagram for this case, giving the tangents of the various bevel angles for normal purlin connections in inches in 12 for any slope.

The utility of such a diagram is best appreciated where the roof surface is curved, as is generally the case in conservatory roofs, or as is frequently the case where the roof surface is curved for a short distance at the eaves for æsthetic reasons. Figs 13 and 14 cover the bevel angles for normal purlins in hexagonal and octagonal turrets of any slope, and Fig. 15 gives the tangents of the bevel angles for jack rafter connections for any slope, "B" equaling 45°. Where two different slopes form a hip or valley, we should figure I by the usual formulas for both slopes, and if the determination of B has been correct, we should arrive at the same result, since I is common to both slopes.

Special Connections.—Where a valley rafter is intersected by a main truss of one roof, it frequently happens that a purlin comes in such a position that it is more convenient to connect to the back of the truss. Let us call the two slopes forming the valley a and b and let the truss lie in slope a. Suppose, for instance, that the purlin is a tee, and we wish to connect the flange by a bent plate to the back of the truss. Use the previous notation for the bevel angles, but add the sub-letters a and b to distinguish the bevel angles for the two respective roof planes.

Then the angle of bend of the plate, measured normal to the bend line, equals (G_a + Gb). The amount the angle, between the center line of the purlin and bend line, differs from 90°, equals Pb. The amount the angle, between the bend line and the center line of truss, differs from 90°, is P_a; all of which are known when the usual set of angles have been figured for the two slopes.

When slope b = 45°, and C = 90°, the bevel angles for a bent plate connection to the stem of the tee purlin, would be the same as for the flange; while for the general case we should be obliged to figure new angles. Take comp. b and a as new roof planes, and C as before, and determine P_a^1, P_b^1, G_a^1 and G_b^1 by the preceding formulas, and we have the necessary angles, the angle of bend of the plate, normal to the bend line being (G_a^1 + G_b^1), or its supplement; depending on which side of the stem it is attached.

Where a valley is short, it may be frequently made up advantageously of two angles, one leg of each lying in a roof plane. The two may be connected together by a bent plate, whose angle of bend, if it connects the legs that are normal to the roof planes, will be (G_a + Gb), or the supplement of this angle, if it connects the legs lying in the roof planes. Bearing in mind the fact that any plane parallel to the plane of web of a normal purlin, intersects the face of the leg of the valley angle which is normal to the roof plane, in a line at right angles to the center line of the face, the connection of such an angle to a truss at its foot, or to a normal purlin at the top is very simple. These connections are shown by Fig. 16.

Shop Work.—Every reasonable expedient should be employed by the draftsman to reduce the shop work to a minimum. Bent plates should be figured from the back of the bend, since these are the distances which the template maker uses in laying off the position of holes for the template. Perhaps this statement will be clearer if we define the back of bend as the intersection of the planes of the outside faces of the bent plate. Where the bend is an acute angle, the plate bends in a curve short of this line, for which a slight allowance may be made in ordering, but the figures should be given as stated.

A little ingenuity will frequently enable the draftsman either to avoid entirely some bent plate connections, or to make them in a manner involving the least work to himself and the shop. Thus a small dormer roof has two troublesome little valleys; which may be detailed, where the dormer ceiling is at the eaves, by cantilevering the purlin from a rafter spaced at the foot of the valley, as shown by Fig. 17, a type of dormer frame used by the writer for the asylum roof at Cherokee, Iowa.

Similarly, we may support the purlins near a valley, formed, for instance, by the intersection of a roof plane and a conical turret roof; instead of attempting the troublesome task of providing a curved valley rafter.

Where the roofing is tile, supported by tee or angle iron purlins spaced from 12 to 20 ins. centers, considerable expense may be avoided by fastening the angle or tee purlins to the rafters by clips and bolts, instead of punching the purlins and bolting them direct to the rafters. The tees or angles can then be shipped plain, direct from the mill to the building, thus avoiding the expense of handling, punching and making detail drawings for them. Fig. 18 shows suitable malleable iron clips for the above connections, also special clip for connecting the hip rafters, and a suitable casting for a valley rafter to which to clip the tee purlin.

Where the cuts are irregular (for clearance) at the ends of beam or channel purlins, they are frequently made by heating the end of the beam or channel, and cutting while hot. If the cut is a plain one, as, for instance, where two I-beam purlins meet above the hip truss or rafter, and there are a number of cuts to make alike, the cheapest and neatest way is to make a block, to which the beam can be bolted at the inclination transversely it will have in the roof, and cut it on the cold saw, skewing the beam the angle B to the plane of the saw.

Where the web of a jack rafter is connected to the web of a valley rafter by a bent plate, especially if the slope of the roof is steep, bad cuts have to be made in the jack to clear the flange of the valley. We may avoid this in the simple manner shown in the Fig. 19, by riveting an angle to the web of the valley rafter, and connecting the web of the jack to the outstanding leg of this angle by a bent plate. Reentrant cuts in bent plates should be avoided where possible.

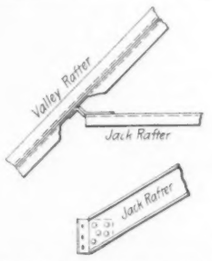


Fig. 19. Special Detail for Jack and Valley Rafter Connection.

Since many pieces in complicated roof work have their lengths given to a reference point, whose position is beyond the end of the member, it is hard for the inspector to check such work accurately, and for that reason extra care should be used in checking the templates and laying out the work.

Clearances.—As the draftsman becomes familiar with the bevel angles in roof work he will rarely make a layout for clearances, the depths of the cuts to clear the flanges of hip or valley rafters being quickly determined by the slide rule, when we have the bevel angles figured and their functions tabulated. For the beginner, perhaps, the practice of making a few graphic lay-outs for clearance for purlins and jacks will prove desirable.

Some draftsmen, indeed, determine all the bevels graphically, but the objection to this is that besides taking very much more time than the analytical method, the angles cannot be determined as accurately as by the common slide rule, and there is greater liability of error; furthermore, the only check in using the graphic method is to lay the work out over again, while two settings of the slide rule will generally check a whole set of angles, by the analytical method. Always allow ample clearance, as it costs no more to give it and saves time in checking.

The reduction of distances figured in the reference plane is simple, when the bevel angles are known, and the following cases only will be considered:

(a) The reduction in length of a purlin, for the half thickness of web of hip or valley.

(b) The difference in length of the purlin to the bend line of the plate, and to the end of the purlin on the center line of the purlin, due to the half thickness of web of purlin.

Let t = the half thickness of web of hip.

Let W = the half thickness of web of purlin.

Then (a) = t cosec B.

(b) = W tan P.

Then the deduction from the length of a purlin figured to the intersection, to get its length to the bend line, equals t cosec B-W tan P, where the plate is on the lower side of a purlin connecting to a hip, or on the upper side of a purlin connecting to a valley. Equivalent but longer values for this deduction are: (t sec M sec V-W tan P) and (t sec G sec P-W tan P).

Having assumed the normal distance d_1 (Fig. 20), from the line of intersection of the planes, through the centers of the webs of the hips and purlins, to the open holes for this connection, to find the distance d_2 from the line of back of bend to these holes. Let t equal the half thickness of web of hip as before, and W the half thickness of web of purlin; then,

$$d^2 = d_1 + t \tan M\text{-}W \sec M.$$

When a bent plate connection forms an acute angle there is frequently trouble in making the connection in the field. Generally, this may be avoided by an expedient similar to that shown in Fig. 19, namely, riveting on an angle somewhat short of the intersection point, and connecting the bent plate to the outstanding leg.

THE RATING OF STEAM AND HOT WATER BOILERS FOR HEATING PURPOSES.*

By James Mackay, Chicago, Ill.

The capacities or power of all boilers, excepting those made solely for heating purposes, are satisfactorily determined according to well-established standards, and boilermakers understand that a given capacity may be developed from certain given dimensions and conditions.

The manufacturers of heating boilers, however, do not determine the capacities of their product with any degree of uniformity. Some rate the capacity higher, others lower, than the grate and heating surface would seem to warrant, and hardly any two agree, even approximately, upon the capacity of boilers that are apparently alike and which should develop about the same power.

Perhaps it is just to assume that the commercial ratings, which prevail among makers of heating boilers, are all based upon different conditions, and are therefore made in good faith; but it would be a distinct advantage if the varying conditions were made to harmonize, and standards established upon which to base capacities.

The temperature of water, or the pressure of steam, affect the capacity developed; but perhaps the most important condition is the amount of fuel consumed per square foot of grate per hour. The writer has made some tests and experiments, with a view of ascertaining the value of fuel, the quantity of heat absorbed per square foot of boiler-heating surface, and the amount emitted per square foot of radiation. The fuel used was a good quality of Pennsylvania anthracite coal; the grates upon which it was consumed averaged 50% air space; the boiler surfaces were flat, round, vertical and horizontal, and at angles from 30 to 45°, the distance of the heating surface from the surface of the fire varying from 20 to 40 ins.; the course of the heated gases and products of combustion were such as to render as much as possible of the heating surface effective, and to bring them to the chimney at a comparatively low temperature. The radiation was a well-known, two-loop pattern, prime cast-iron surface, 38 ins. high, and, as the manufacturers' rating of surface was found to be slightly inaccurate, due allowance for this was made. The conditions under which the tests were conducted were such as are usually met with in ordinary practice, care being taken to avoid and eliminate anything of an unusual nature. Where the radiators were placed, the average temperature maintained was 70° F., the external temperature varying from 10° F., above zero, to 0° F., and the conditions of the atmosphere being normal. While the effective thermal value of 1 lb. of good coal was found to be, in many instances, greater than 10,000 B.T.U., it was considered that this was a conservative value. By comparing the weight of coal consumed with the different temperatures of water, fire and flue, and the weight of the water of condensation at different pressures, the value of boiler surface was determined. The cubic feet of air raised to 70°F., at different temperatures, was ascertained, and from the result the number of heat-units emitted by 1 sq. ft. of radiation was computed. The following table gives the amount of air heated 70°F. by 1 sq. ft. of radiation, at different temperatures in the steam and water:

Temperature; steam in radiators.	Air raised 70°F. by 1 sq. ft. of radiation.	Temperature; water in radiators.	Air raised 70°F. by 1 sq. ft. of radiation.
212°F.	189 cu. ft.	140°F.	79 cu. ft.
215°F.	194 "	150°F.	93 "
219°F.	201 "	160°F.	107 "
222°F.	207 "	170°F.	121 "
225°F.	213 "	180°F.	137 "
227°F.	217 "	190°F.	153 "
230°F.	222 "	200°F.	169 "
		210°F.	185 "

*Condensed from a paper read at the New York meeting of the American Society of Heating and Ventilating Engineers.

In this connection it is interesting to note that Mr. Kaeuffer, M.E., of Germany, has made the following deductions from careful tests as to the value of radiating surfaces, based, however, upon steam pressures, varying from 10 to 15 lbs.:

	Per sq. ft., per hour.
Smooth, vertical, flat W. I. surface emits....	406 B.T.U.
Vertical, pipe surface emits.....	480 "
Horizontal, pipe surface emits	369 "

These results would closely correspond to our practice by reducing the pressure to those used in America.

Mr. A. R. Wolff, M.E., following the same investigation, at a steam pressure of about 2 lbs., gives the following results:

	Per sq. ft., per hour.
Bronzed C. I. radiators (American make)....	250 B.T.U.
Plain (not bronzed) C. I. radiators (Am. make)	400 "

and the same radiators emit 60% of these amounts for hot water.

As the pressure Mr. Wolff gives is somewhat indefinite, the results are valuable only in a general way.

Mr. F. Schumann, C.E., in many valuable tables, gives the heat emitted per square foot of steam and water-radiating surface per hour, at different temperatures in B.T.U., based upon the experiments of Péclet. His formulas are made from accurate deductions, and the results compare closely with those of Professor Carpenter, Mr. Baldwin and other American authorities. Foreign writers, however, although giving us much information as to details, and using practically the same methods of computation, give results that rate boilers much higher than our practice would warrant, this being due to different conditions and requirements.

The average absorbing value of heating surface varied from 2,000 to 2,800 B.T.U. per sq. ft. per hour. By increasing the temperature of the fire and the quantity of fuel consumed, higher averages were obtained; but in view of the attention required, they could not be termed conservative.

Boilers containing the largest percentage of direct fire surface, approaching 75% of the total surface as a limit, developed the highest efficiency; but when this limit was exceeded, the chimney temperature increased, and the operation of the boiler became unsteady, showing that less than 25 to 30% of flue surface was undesirable.

The results obtained from different proportions of fire and flue surface are here given:

Surface, Fire	Surface, Flue	B.T.U. absorbed per sq.ft. of heating surface (ave.).
25 to 30%	70 to 75%	2,000
35 " 40%	60 " 65%	2,200
45 " 50%	50 " 55%	2,400
55 " 60%	40 " 45%	2,600
65 " 70%	30 " 35%	2,800

Small boilers contained a lower proportion of fire surface, and sustained a greater loss of heat than large ones, from local radiation; therefore, greater efficiency developed as the size of the boiler was increased.

The ratio of increase was as follows: Up to 3½ sq. ft. of grate, 2,000 B.T.U. absorbed per sq. ft. of heating surface (average); up to 5½ sq. ft., 2,200 B.T.U.; up to 9 sq. ft., 2,400 B.T.U.; up to 13 sq.ft., 2,600 B.T.U.; up to 20 sq. ft., 2,800 B.T.U.

This ratio was observed while using the proportions of heating surfaces previously given, and of course, would vary if the proportions were changed.

But, after all, the fuel is the fountain head, as the quantity consumed practically governs the capacity of a given boiler; that is, up to the absorbing limit of its heating surface. Now, it would seem quite feasible for manufacturers of heating boilers to adopt as standards a certain pressure for steam boilers, and a given temperature for water heaters; then to base ratings upon the thermal value of fuel consumed per square foot of grate, the absorbing value of boiler heating surface, and the heat emitted per square foot of radiation. With these values decided upon, if only approximately, the situation would be much clearer.

The two tables here given are results of tests outlined and are based upon the following formula:

Let A = thermal value of coal;
B = B.T.U. emitted per sq. ft. radiation per hour at 70° F.;
C = lbs. coal burned per sq. ft. of grate per hour;
D = B.T.U. absorbed per sq. ft. effective boiler surface per hour (average);
X = sq. ft. of radiation per sq. ft. of grate;
Y = minimum sq. ft. of effective heating surface per sq. ft. of grate,

Then

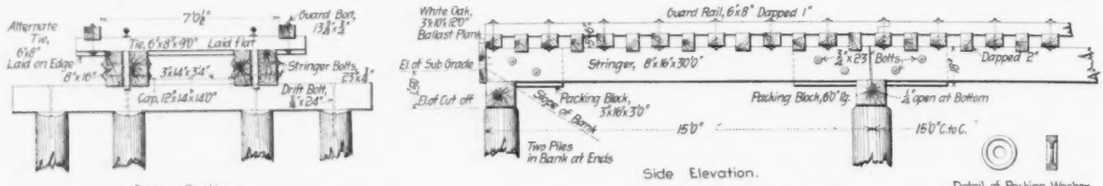
$$X = \frac{AC}{B}, \text{ and } Y = \frac{AC}{D}.$$

The value of A in this formula is taken here at 10,000 B.T.U., and the different values of the other reference letters are given in the table below. The quantity of coal consumed per square foot of grate per hour is given in the first column at the left; the next columns give the square feet of radiation per square foot of grate, for different

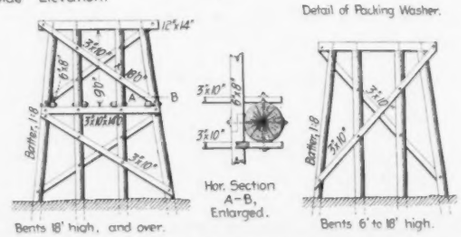
	Water.							Steam—Lbs. At-						Minimum sq. ft. effective heating required per sq.ft. grate.				
								mos.	1.	2.	3.	4.	5.	6.					
Temperature, deg. F.....	140	150	160	170	180	190	200	210	212	215	219	222	225	227	230					
B.T.U. emitted per sq. ft., radiation per hr. at 70° F..	115	135	156	177	199	222	246	270	275	283	293	302	310	316	323					
	Sq. ft. radiation pr sq.ft. grate																			
Coal per hour per sq. ft. of grate.. 10 lbs.	.869	741	641	565	502	450	406	370	363	353	341	331	322	316	309	35⅜	38¼	41⅔	45½	50
9 "	.782	666	577	508	452	405	366	333	327	318	307	298	290	285	278	32⅛	34⅔	37½	41	45
8 "	.695	592	513	452	402	360	325	296	291	283	273	265	258	253	248	28⅝	30¾	33⅓	36½	40
7 "	.608	518	448	395	351	315	284	259	254	247	239	231	226	221	216	25	27	29⅙	31⅞	35
6 "	.522	444	385	339	302	270	244	222	218	212	205	199	194	190	186	21⅜	23	25	27½	30
5 "	.435	370	321	282	251	225	203	185	182	177	171	166	161	158	155	17⅝	19¼	20⅚	22½	25
4 "	.348	296	256	226	201	180	163	148	145	141	137	132	129	127	124	14⅜	15⅜	16⅔	18⅛	20
3 "	.261	222	192	169	151	135	122	111	109	106	102	99	97	95	93	10⅜	11½	12½	13⅝	15
B.T.U. absorbed per sq. ft. heating surf. per hr. (avg.):									2,800	2,600	2,400	2,200	2,000							

coal burned per hour," and dividing the figures in the first line under the former heading by 10. A single line of figures would then give the ratio A ÷ B for the several temperatures of steam, and for the given conditions of efficiency of radiation surface, and of quality and effective heating value of coal.

Mr. Wm. Kent that Mr. Mackay's table might be condensed into a more handy form by substituting for the heading "sq. ft. radiation per sq. ft. grate," "sq. ft. radiation per lb. of



STANDARD PILE TRESTLE; ST. LOUIS, PEORIA & NORTHERN RY.



CONSTRUCTION OF THE ST. LOUIS, PEORIA & NORTHERN RY. *

By F. G. Jonah.†

In 1897 the St. Louis, Peoria & Northern Ry. extended its line from Springfield to a connection with the Peoria & Pekin Union Ry. at Grove, near Peoria, a distance of 57.56 miles. The distance between the cities of Springfield and Peoria was thereby shortened to 63 miles, a saving of 24 miles over existing lines. The location of the line is generally due north, and 53 miles of the total distance is made up of tangents.

There is one 4° curve in the yard at Springfield, and one 3° 30′ curve in the connection with the P. & P. U. R. R. at Grove, so that 2° is practically the maximum. The longest tangent is 9.52 miles.

The grades are comparatively easy, as the following table will show:

Level	13.181 miles.
Grades from 0.01 including all 0.10%.....	8.053 "
Grades over 0.10 including all 0.20%.....	3.394 "
Grades over 0.20 including all 0.30%.....	9.940 "
Grades over 0.30 including all 0.40%.....	3.627 "
Grades over 0.40 including all 0.50%.....	5.141 "
Grades over 0.50 including all 0.60%.....	6.048 "
Grades over 0.60 and less than maximum...	3.006 "
Maximum, 0.66	5.170 "

The standard roadbed in cuts is 22 ft. base, with side slopes of 1 to 1. Embankments, 16 ft. crown, with slopes of 1½ to 1.

The track is laid with 75-lb. rails, spliced with 26-in. angle bars with four ⅞-in. bolts to the joint. There are 16 ties to the rail length. The rails are laid with broken joints, and the track has 6 inches of gravel under the ties.

The line crosses the Sangamon, Salt Creek and Mackinaw rivers, at which places there are through trusses resting on concrete piers. The spans at Sangamon and Salt rivers are 175 ft.; that at Mackinaw is 160 ft. At the smaller streams there are trestles of the standard plan illustrated herewith. There are 11 stations on the line.

The line crosses the Wabash R. R. near Springfield, the Chicago & Alton R. R. at Sherman, the Illinois Central R. R. at New Holland, the Chicago & Alton R. R. by under-crossing at San Jose, the Peoria, Decatur & Evansville R. R. at Green Valley, a switch of the same road at Hawley, and the Big Four and Santa Fe railways at Pekin. The following crossings are protected by interlocking plants installed by different companies:

Wabash R. R. crossing.....	National Switch & Signal Co.
Sherman	" " "
Green Valley	Standard Signal Co.
Hawley	Rowell-Potter Safety Stop Co.
Big Four & Santa Fe Rys...	National Switch & Signal Co.
P. & P. U. R. R. crossing..	" " " "

The line passes through the very center of the corn belt, where the land is very highly improved. Some ten miles of the right of way had been purchased by the old St. Louis & Chicago Ry. in 1886, leaving 47½ miles which the St. L., P. & N. had to purchase. The average cost was $200 per acre, and twelve acres to the mile.

The contract for grading was let at a low figure, but the quantity moved was above the average for a prairie country, due to the easy grade line, thus necessitating heavy work at several points. There are heavy cuts each side of the Sangamon and Mackinaw rivers and one at San Jose containing 90,000 cu. yds. This heavy cut is due to the under crossing of the Chicago & Alton R. R. The earthwork averaged about 23,000 cu. yds. to the mile and cost $3,000 per mile. The large cuts were all hauled to make necessary embankments and the earth was moved by cars loaded by laborers with shovels. Light fills were made with slips, and small cuts were taken out with wheelers. In some instances it would have been cheaper to waste the dirt from cuts and borrow for embankments, but that method would take longer to complete the work, besides giving a much more untidy appearance to the grade.

There are 6,495 ft. of trestle on the line, which cost an average of $5.75 per lin. ft. The steel trusses on concrete foundations cost $30,000. The small sized station buildings, 14 x 22 ft. in plan, cost $400. Standard combination station, 16 x 40 ft., cost $850. The large size station and freight shed at Pekin cost together $2,000. The interlocking plants cost an average of $212 per lever. The track work was comparatively cheap, as the rails were purchased for $18 per ton. Spikes, bolts and angle bars were also purchased for very low figures.

The average cost per mile of track, exclusive of shops and equipment, is made up approximately as follows:

Right of way.....	$2,400
Grading	3,000
Trestles	600
Steel bridges	500
Track work, rails, ties and ballast.....	5,000

*Abstract of a paper read at the annual meeting of the Illinois Society of Engineers and Surveyors at Moline, Ill.

†Engineer of Maintenance of Way, Chicago & Alton R. R., at Bloomington, Ill., formerly Resident Engineer of the St. L., P. & N. Ry.

Station buildings	117
Water service	13
Interlocking plants	400
Fencing	250
Pipe culverts	50
	$12,406

The contractors were as follows: Grading, J. A. Ware, St. Louis; trestles, Burnet & Lutes, St. Louis, Mo.; steel bridges, Phœnix Bridge Co., Philadelphia, Pa.; concrete masonry, Barron & Peace, Marseilles, Ill.; stations, McGrue & Powell, Springfield, Ill.; fencing, Vandeventer Fence Co., Chicago; tracklaying, Faught & Gridley, St. Louis.

The work was done under the direction of Mr. Robert Moore, M. Am. Soc. C. E., Chief Engineer, and the writer was Resident Engineer.

From blue prints of the standard plans furnished us by Mr. Jonah, who was Resident Engineer on the line, we have selected the drawing reproduced in the accompanying cut. It shows the standard pile trestle construction, which is peculiar in the arrangement of the ties. All the ties are 9 ft. long, 6 x 8 ins. in section, and they are laid alternately flat and on edge, the former resting on the stringers, while the latter are let 2 ins. into the stringers. The guard timbers are boxed out or dapped 1 in. for all the ties, and are bolted to the flat ties.

It may be noted here that the St. Louis, Peoria & Northern Ry. was absorbed by two larger companies in December, 1899. The new line above described, from Springfield to Peoria, was taken over by the Chicago & Alton R. R. The old line south from Springfield to St. Louis (including running powers over the Merchants' Bridge, and over the Chicago, Peoria & St. Louis Ry. for 17 miles from Glen Carbon to East St. Louis) was taken over by the Illinois Central Ry.

RETAINING WALL OF CONCRETE WITH METAL SKELETON.

In connection with the Paris Exposition of 1900 it was found expedient to construct a temporary sunken street, near the gardens of the Trocadero, for the better accommodation of the crowds of visitors. This street is 46 ft. wide and is 18 ft. below the general surface; and the ground to be held up by the retaining walls was made up of debris of all kinds, which would have required, by adopting ordinary methods of retaining wall construction, a mass of costly masonry inconsistent with the temporary character of the work. In this emergency the engineers decided to make these walls of "beton-arme," a name which French engineers have given to constructions of concrete containing an embedded metal skeleton of wire mesh, expanded metal or similar material.

As described in "Le Genie Civil," of Sept. 30, 1899, the Hennebique system of combined concrete and steel construction was employed. The trench for the street is made up of two slopes, with an average gradient of 2.5%, meeting under the Jena bridge, in a level of about 98 ft. The retaining walls along this trench are divided into panels averaging 6 m. (19.7 ft.) in length, and each of these panels is made up of a facing of "beton-arme," from the back of which project three buttresses of similar construction. The facing and buttresses are connected by two horizontal beams of "beton-arme." Another buttress projects from the face of the retaining wall and is located a certain distance below the street level. This construction is clearly shown by Figs. 1 and 2.

By this arrangement of horizontal beams the retaining wall is assisted in sustaining the earth by the weight of this earth upon the horizontal beams; and does not, as in ordinary retaining walls, depend upon its weight alone. The employment of the two separate beams at different levels, instead of one of the same total width, results in largely decreasing the thrust of the earth upon the vertical face; and by this arrangement there is also less earth to move in building the wall. The two rear-beams, however, are only used in the nine panels on each side of the Jena bridge, as beyond that the height of the wall is so small that the second beam can be omitted.

In calculating the elements of this wall, an angle of 35° was assumed for the safe slope of the earth, and a weight of 112 lbs. per. cu. ft. was taken for the earth itself. For each lineal meter of the wall it was assumed that a part of the overturning tendency would be counteracted by the weight of the earth upon the rear-beam, and that the corresponding buttresses would work in tension; while the other part of this moment would be met by the resistance to compression of the front buttresses and beams. The width of the front horizontal beam was fixed by assuming a

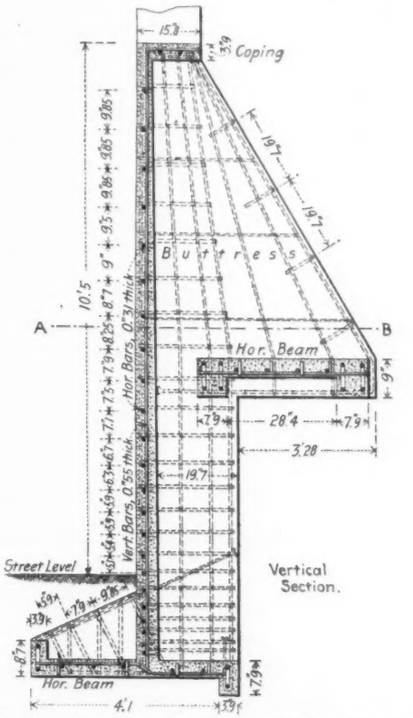


Fig. 1.—Transverse Section of Retaining Wall of Concrete with Embedded Metal Skeleton.

safe load of 2,048 lbs. per sq. ft. upon soil of this nature; the width of the back-beams was figured with an average factor of safety exceeding 2, in calculating the moment of stability of the wall.

The embedded metal work of the vertical face consists of two series of vertical bars combined

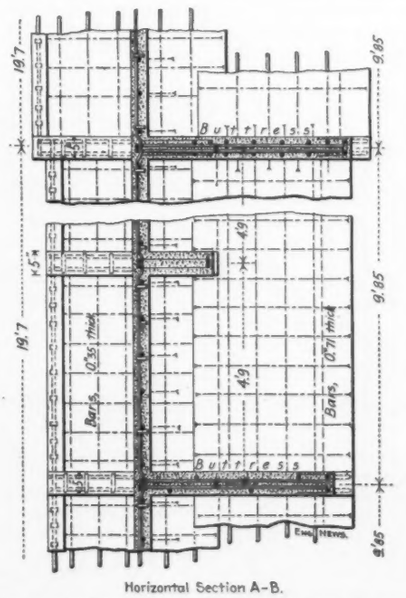


Fig. 2.—Sectional Plan of Retaining Wall of Concrete with Embedded Metal Skeleton.

with one series of horizontal bars, the spaces between which increase towards the top of the wall. These vertical bars are bent over at right angles at the top to give support for a coping of the same construction as the facing. The illustrations show the construction of the buttresses, which are composed of inclined bars, tied together by straps, and supported by horizontal bars. The horizontal beams are made up of bars in both directions, spaced five bars to the sq. meter; and at their edges these beams are further strengthened by flanges. The concrete used was made by hand, in the proportion of 300 kilos. of slow-setting cement to 1 cu. m. of gravel and sand.

In connection it may be interesting to note that across the middle of the depressed roadway was a bridge, of the same type of construction as the wall. The retaining walls described formed the abutments for this bridge. This bridge is 100 ft. wide, including a roadway and two sidewalks; and the roadway is 10 cm., or 4 ins. thick, supported by 12 arched beams, with a rise of 2 ft. in a span of 46 ft. These beams are 12 ins. deep at the crown, and 2 ft. 11½ ins. deep at the spring; and 10 ins. and 33 ins. wide, respectively. These arched beams are tied together by four cross-beams, 10 ins. high by 8 ins. wide, spaced about 9 ft. 2 ins. apart.

THE RED RIVER CANAL PROJECT is up again in the form of a ship canal ultimately to connect Lake Superior and Grand Forks, North Dakota. A congressional bill has been prepared providing for the building of the canal. Mr. Lyman E. Cooley, M. Am. Soc. C. E., has carefully studied the problem, and he says the best route starts at Bay St. Louis, near Duluth, passes up the St Louis River to Sandy Lake; then northerly and westerly by the upper Mississippi River and a series of small lakes to Lake Winnebigohish; thence across the watershed to Red Lake; by Red Lake River to the Red River of the North and to Grand Forks. The elevations to be overcome are as follows: The elevation of the western end of Lake Superior is 600 ft. above tide; Sandy Lake has an elevation of 1,298 ft.; watershed elevation, 1,311 ft.; Red Lake, 1,150 ft.; elevation at Grand Forks, 784 ft. The canal would be about 350 miles long, though the direct distance is only about 250 miles. The country traversed is a national forestry reserve, wild and undeveloped. The improvement of the Red River is included in the project. The cold northern climate is a drawback to the scheme, and the canal could only be used for five or six months in the year. Mr. Cooley says that the canal would be useless unless it carried vessels of 1,200 to 1,500 tons; and such a canal would have to be at least 100 ft. wide and 12 to 15 ft. deep.

A MOVE FOR WATER FILTRATION AT ST. LOUIS, headed by the Engineers' Club of that city, gives promise that the many long years of procrastination will soon be at an end. The late James Kirkwood, it will be remembered by some, recommended filtration for St. Louis over thirty years ago, in his classic report on "The Filtration of River Waters." Recently the Board of Public Improvements has tried to initiate the much-needed work, but the Municipal Assembly has refused to act in the matter. On Jan. 26, some 50 citizens, including representatives from 21 local organizations, met on invitation of the Engineers' Club of St. Louis to discuss the water question. A Citizens' Committee on Water Filtration was organized, with Mr. C. H. Huttig president and Mr. M. L. Holman, M. Am. Soc. C. E., as one of the five vice-presidents. Maj. J. L. Von Ornum was elected temporary secretary. Dr. Amand Ravold, City Bacteriologist, referred to the typhoid epidemics of 1892 and 1899. In 1892 there were 3,385 cases and 442 deaths, and in 1899 there were 707 cases and 69 deaths. Both epidemics, he said, followed periods of low water in the Illinois and Missouri rivers. At times of high water, he mentioned, the bulk of the supply is really Missouri River water, but when the water is low the main stream of the Mississippi is drawn from to a greater extent, and thus more Illinois River water is taken. Dr. Ravold strongly condemned the Chicago drainage canal. The joint committee adopted resolutions to the effect that the river water "is frequently turbid and is becoming increasingly polluted;" that filtration is feasible and efficient; that an unobjectionable water supply is desirable before the "World's Fair is held in this city," and:

Whereas, The recent changes in disposing of the sewage of Chicago materially increases the menace to the health of this city from its water supply; therefore the assembled delegates from 21 organizations in this city, representing about 7,000 members of such organizations—

Resolved (1), That the water supplied to the people of this city should be filtered by the city.

(2) That the Board of Public Improvements and the Municipal Assembly of St. Louis are hereby respectfully requested to take the proper action to inaugurate, as soon as possible, such preliminary investigation as may be necessary to determine the system of filtration best suited to the peculiar local conditions of our water supply.

(3) That the same city authorities be further requested to take such action, based on this preliminary investigation, and the condition of funds available, as shall result in securing, as speedily as possible, the most efficient and economical system of filtration of the water supply of the City of St. Louis.

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ADVERTISING RATES: 20 *cents a line. Want notices, special rates, see page XXI. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.*

One of the chief difficulties in the construction of concrete arch bridges, either when made of solid concrete or of any of the combinations of concrete and embedded steel which are meeting so much favor, is the settlement of the abutment foundations and resulting cracks at the crown. European engineers are meeting this difficulty by placing hinges of various forms at the crown and the springing lines; but these are more or less expensive, and are apt to detract from the appearance of the structure. On another page of this issue, a contributor suggests the use of ties to connect the abutments of such arches and describes experiments on small models which showed that the strength of the arch was multiplied several-fold by the use of such ties, as would indeed be naturally expected with the conditions under which the tests were made. The idea is certainly worth consideration by engineers engaged in the design of masonry arches, especially when they have poor foundations to contend with.

There is no need to take very seriously the bill introduced in Congress by Mr. McClellan on Feb. 7, which proposes the acquirement by the United States of the Erie Canal. An amendment to the Constitution of the State of New York must precede any such transfer, and such an amendment, even if it could command popular support, which is very doubtful, would require three years at least to effect.

The bill directs the Secretary of War, after he secures control of the Erie Canal, to "enlarge it to a capacity sufficient to permit of its use by United States vessels of war of a displacement of 15,000 tons," a displacement thus far reached by only two or three of the largest war vessels ever built. The bill limits the total amount to be expended in the construction of such a canal to $75,000,000. In view of the fact that the recently published estimates for a 1,000-ton barge canal on the Erie Canal route aggregate $60,000,000, and of the further fact that right of way and water supply difficulties make a ship canal on the Erie Canal route well nigh impossible, it would be advisable to add another cipher to the $75,000,000.

The laboratory section of the American Public Health Association, established at the recent Minneapolis meeting, is a feature which met with hearty support at the start and promises to add greatly to the usefulness of the association. It is proposed to set apart one day of each annual convention for the consideration of technical questions of interest to those engaged in laboratory work. The chairman of the section for the present year is Dr. Theobald Smith, of Washington, D. C. As the "Ohio Sanitary Bulletin" for October-November well says:

> A result of the annual meeting of laboratory men working along sanitary lines will doubtless be a much greater uniformity in methods of work and the recording of results.
>
> A good deal of half-worked material has been published by some of our too ardent bacteriologists. The medical profession as well as the laity have been misled in some instances. The laboratory section will offer a place, it is hoped, for the presentation of original work of merit. Conclusions accepted by the section will undoubtedly find credit in all circles.
>
> It has been suggested that possibly grants of money for research work along sanitary lines may be made to the association, and be referred by the laboratory section to some competent commission.
>
> One of the effects we may hope for is the establishment of laboratories by all state boards of health, and we will look to this new section for suggestions as to how such laboratories may be made more and more useful in selecting measures for the protection of the public health.

Further information regarding the section can be obtained from the chairman, or from Dr. C. O. Probst, Columbus, O., Secretary of the association.

Many of our readers will recall, we are sure, a paper entitled "Cylindrical Wheels and Flat-Topped Rails," read ten years ago before the American Society of Civil Engineers by Mr. Don. J. Whittemore. In this paper Mr. Whittemore urged that to meet the constantly increasing wheel loads of modern railway service the top of the rail should be made flat and the contour of the wheel tire straight, in order to get as great a length of bearing surface of the wheel on the rail as possible.

We are reminded of this paper in examining the details of the 150-ton crane, illustrated on our inset sheet last week. The tipping moment of this crane, due to the load on its projecting arm amounts to 216,000 lbs., when the maximum load is carried, and this moment is transferred to a pair of wheels, each 39 ins. in diameter, with 5 ins. width of face, rolling against a turned steel ring. This is a load per wheel of 108,000 lbs., or about four times the heaviest load per wheel thus far reached on locomotive drivers, even with the very heaviest American passenger locomotives.

Of course the conditions of speed, bearing surface, etc., are totally dissimilar in the two cases; and we call attention to the matter merely as a remarkable illustration of a heavy wheel loading, and an indication that to properly support the heavy wheel loads of modern railway rolling stock we must look to an increased width of bearing surface of the wheels upon the rail.

THE PROPERTIES AND POSSIBLE USES OF NICKEL STEEL.

The world's production of nickel in 1897 amounted to 5,429 tons, the bulk of which came from the Canadian mines and from those of New Caledonia. In 1899 a conservative estimate places the total production of nickel at about 7,000 tons. During the interval between these two dates no new mines of any importance were discovered, the increase recorded being due wholly to the greater output of the well-known nickel producing districts named. These facts are worth noting carefully, as they establish the physical limit of nickel steel production until some new discovery or development of which we now have no indication lays open a greater wealth of nickel ore for our use. Employed in the usual proportion of 3% to 3½% as an alloy of steel, the nickel output of 1899 would make about 230,000 tons of nickel steel. As already stated, these figures establish the physical limit of nickel steel production at the present time. For obvious reasons the commercial limit is much below these figures. Under no circumstances, therefore, which we have any reason to anticipate can nickel steel constitute more than a small percentage of the total steel consumption of the world. This is a fact which it is important to keep in mind in any speculation upon the future development and possible uses of nickel steel in engineering works.

The fact that we so soon reach a limit in the possible production of nickel steel cannot be anything but a matter of regret to engineers. Of all the various alloys of steel which have come into prominence in recent years, that of nickel and steel admittedly presents the greatest promise of general utility for engineering purposes. Considering the truly remarkable properties of the metal, however, the quantity consumed for other purposes than armor plate is, it must likewise be admitted, surprisingly small. One reason for this is, of course, that while the purposes for which it has been chiefly employed are important, they do not call for large quantities of material. A second reason is undoubtedly to be found in the higher price of the alloy as compared with simple steel. Giving these facts all the prominence which is their due, however, it must be acknowledged, we think, that the failure to take full advantage of the opportunities which nickel steel offers as a structural material is due to the fact that engineers are to a considerable extent unacquainted with the true properties and limitations of the material. This lack of familiarity is doubtless unwarranted by any lack of reliable information, but there is no doubt but that it generally prevails, and, moreover, that it is in many instances responsible for the hesitation with which engineers are adapting nickel steel to many uses for which it is particularly well adapted.

We have been prompted to make these remarks by reading the excellent paper on nickel steel, which was presented at the San Francisco meeting of the Institute of Mining Engineers, by Mr David H. Browne, in September of last year. This paper is by all odds the best general summary of the present experience and opinion respecting the properties and uses of nickel steel, which has appeared for some time. In view of the conditions just mentioned, moreover, much of the information which it contains respecting the properties of this useful alloy and particularly the speculations which it suggests respecting its more general adoption in engineering work are of exceptional interest.

At the very outset Mr. Browne points out that the physical tests of metallic nickel furnish no explanation of its remarkable effects when alloyed with iron. The most notable of these effects is the manner in which it increases the elastic strength of the steel to which it has been added. This fact is not exhibited so much by the increase in the elastic limit of the steel as it is by the greatly increased resistance which it develops against numerous and repeated strains. Expressed in another way, the addition of the small percentage of nickel extends the limit at which molecular fatigue begins as distinguished from molecular distortion, which is the elastic limit of the metal. The testing room parlance of America has no well known designation for the former phenomenon, but among European engineers it is commonly known as the "limit of proportionality." The limit of proportionality is always considerably inside the elastic limit, and it is in increasing this that the greatest influence of the nickel alloy is exhibited.

A few figures of the results of tests will demonstrate the nature of the quality just mentioned more clearly. According to tests made by Prof. Rudeloff, of Berlin, an alloy of 8% of nickel with pure iron has 3.8 times the elastic strength of the pure iron. With higher percentages of nickel the limit of proportionality decreases. In tests made by numerous and rapidly alternating flexures at the Pope Tube Works at Hartford, Conn., it has been found that taking 0.1% carbon steel loaded to about 60% of its elastic strength as a basis, and assuming that it will withstand 100,000 flexures,

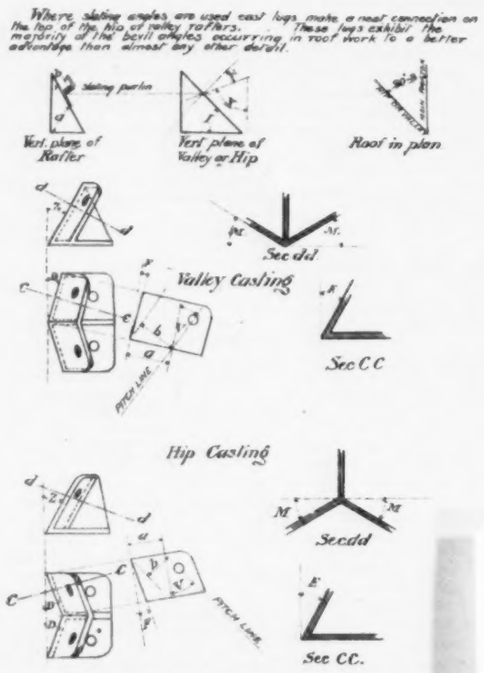
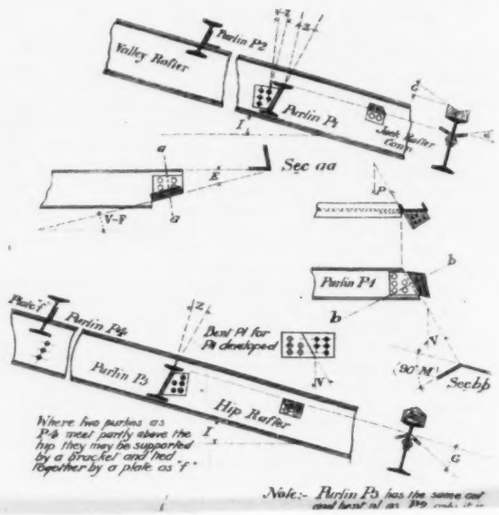
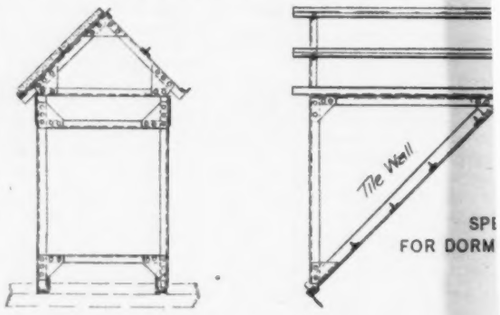

Where skating angles are used cast legs make a neat connection on the top of the hip of valley rafters. These legs exhibit the majority of the bevil angles occurring in roof work to a better advantage than almost any other detail.
Vert. plane of Rafter
Vert. plane of Valley or Hip
Roof in plan
Sec dd
Valley Casting
Sec CC
Hip Casting
Sec dd
See CC.

FIG. 7. TYPICAL HIP AND VALLEY CASTINGS.


Valley Rafter
Purlin P2
Purlin P3
Sec aa
Purlin P1
Purlin P4
Bent Pl for P1 developed
Purlin P3
Hip Rafter
Sec bb
Where two purlins as P3 & P4 meet partly above the hip they may be supported by a bracket and tied together by a plate as 'f'.
Note:- Purlin P3 has the same cut and bent at as P2



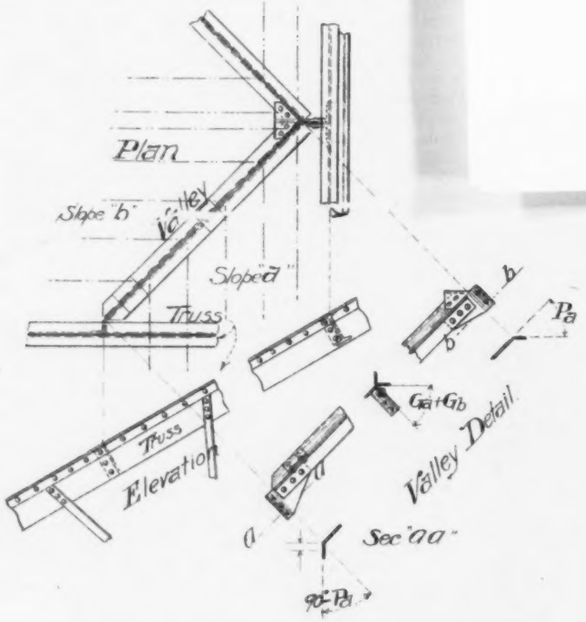


FIG. 16. SPECIAL ANGLE CONNECTION FOR SHORT VALLEYS.

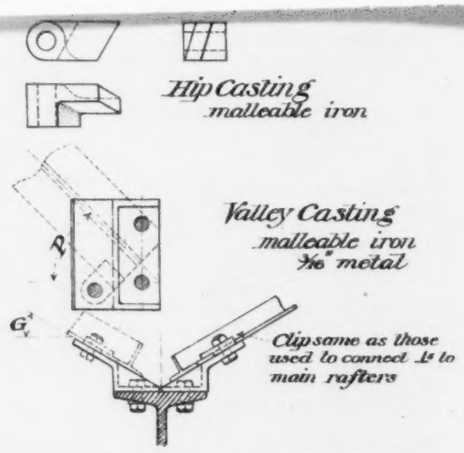


FIG. 18. CLIP CONNECTIONS FOR TEE PURLINS.

TIGHT BOUN

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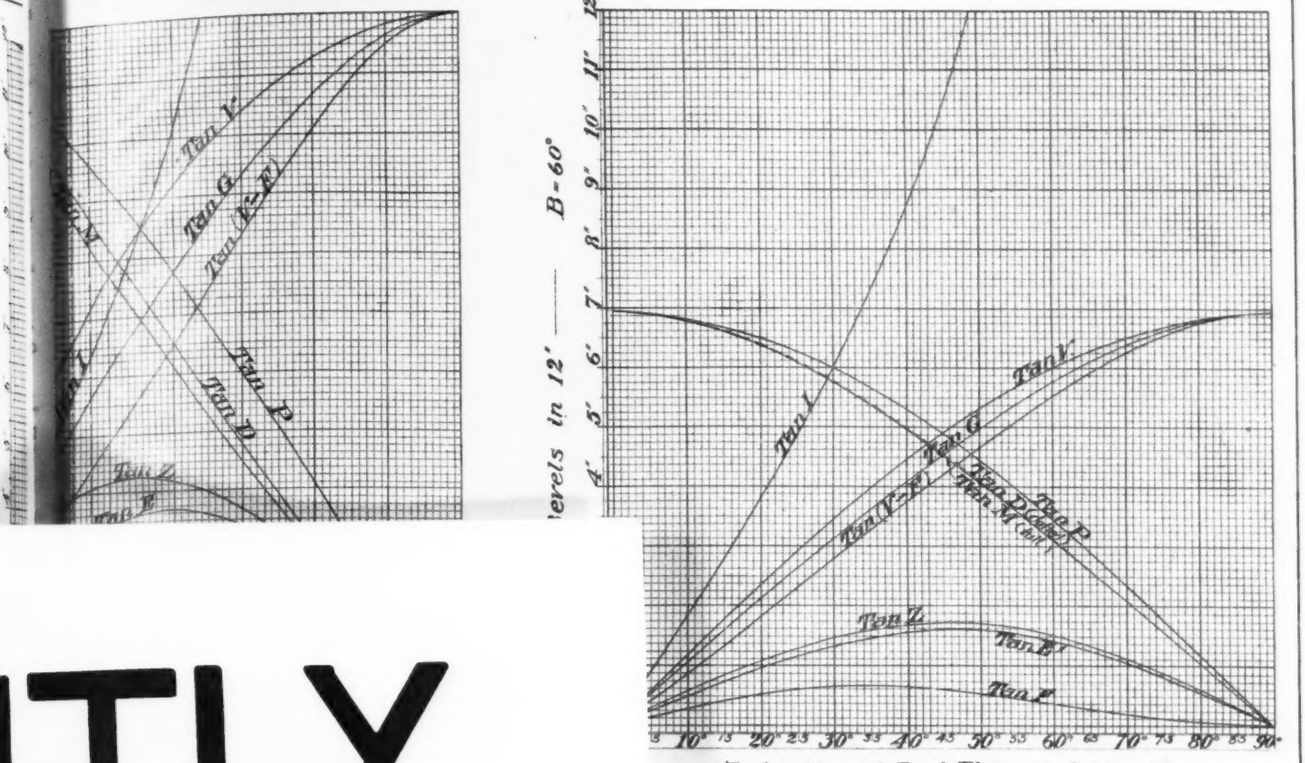
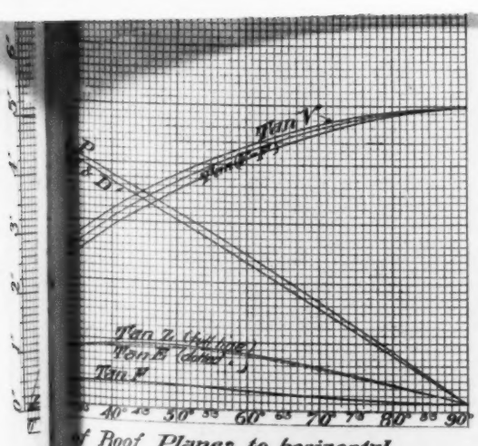


FIG. 13. DIAGRAM FOR DETERMINING BEVEL ANGLES FOR NORMAL PURLINS IN HEXAGONAL TURRET ROOFS.



FOR DETERMINING BEVEL ANGLES
INS IN OCTAGONAL TURRET ROOFS.

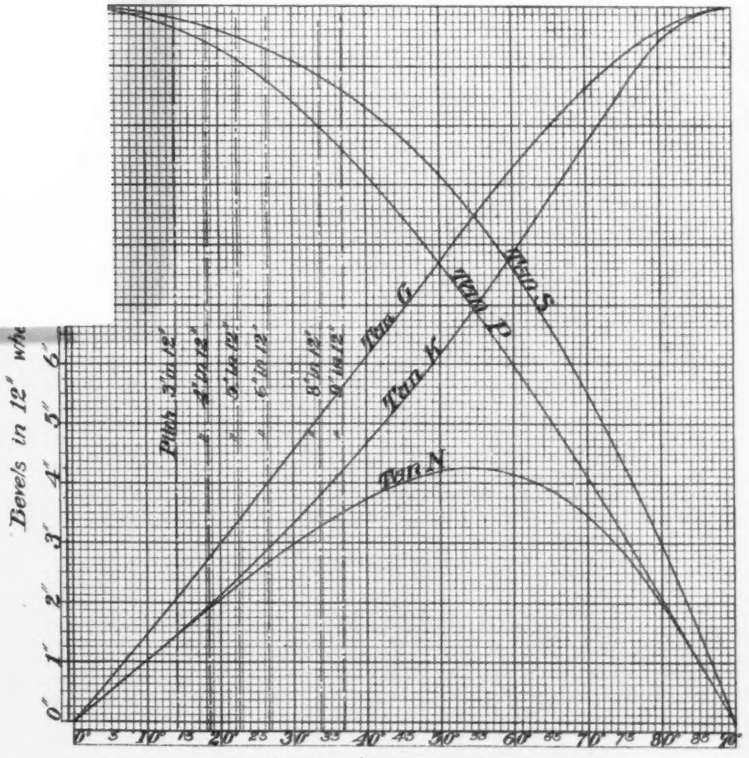


FIG. 15. DIAGRAM FOR DETERMINING BEVEL ANGLES FOR JACK RAFTER CONNECTIONS.

OR ROOF WORK.

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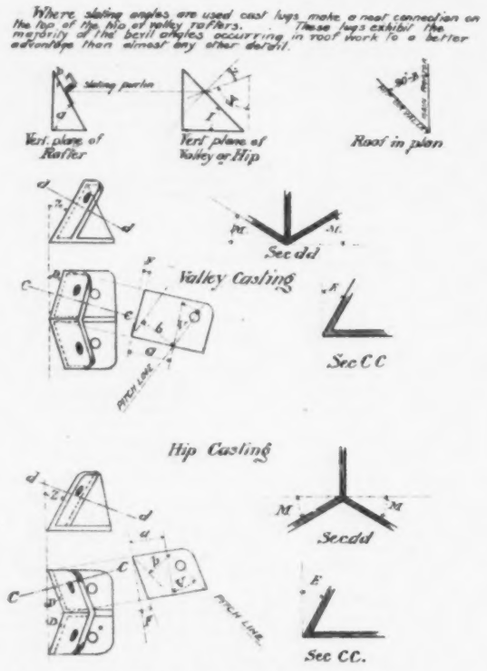
Where slating angles are used cast lugs make a neat connection on the top of the hip or valley rafters. These lugs exhibit the majority of the bevil angles occurring in roof work to a better advantage than almost any other detail.
Slating purlin
Vert. plane of Rafter
Vert. plane of Valley or Hip
Roof in plan
Sec dd
Valley Casting
Sec CC
Hip Casting
Sec dd
Sec CC.

FIG. 7. TYPICAL HIP AND VALLEY CASTINGS.

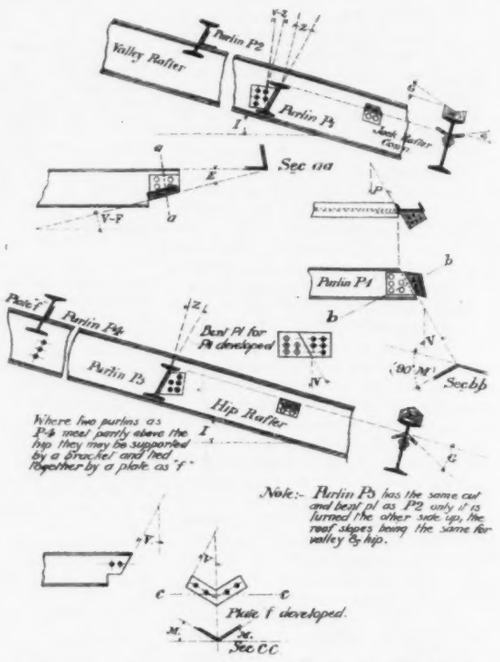
Valley Rafter
Purlin P2
Purlin P3
Jack Rafter
Sec aa
Purlin P1
Plate f
Purlin P4
Bent Pl for P3 developed
Purlin P5
Hip Rafter
Sec bb
Where two purlins as P4 & meet partly above the hip they may be supported by a bracket and tied together by a plate as "f"
Note:- Purlin P5 has the same cut and bent pl as P2 only it is turned the other side up, the roof slopes having the same for valley & hip.
Plate f developed.
Sec CC

FIG. 8. TYPICAL DETAILS FOR PURLIN CONNECTIONS.

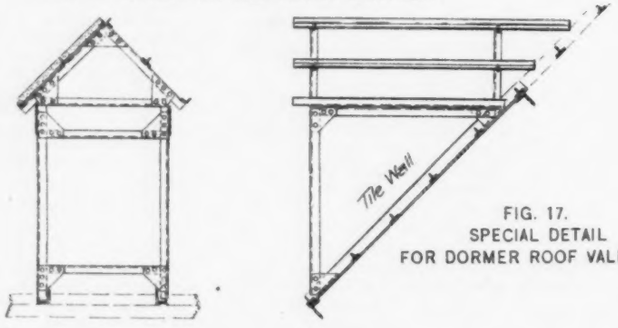

FIG. 17.
SPECIAL DETAIL
FOR DORMER ROOF VALLEYS.

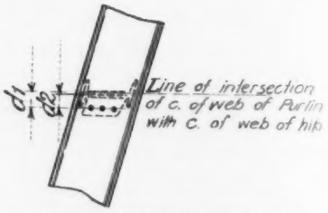

FIG. 20. SPECIAL DETAIL FOR HIP AND PURLIN CONNECTION.

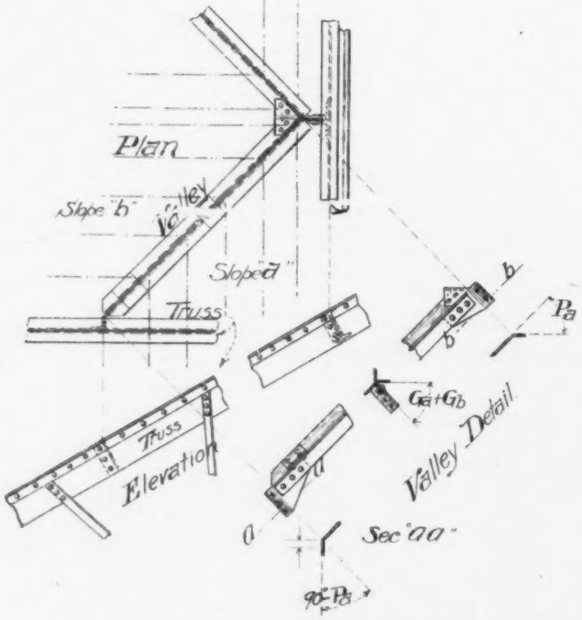

FIG. 16. SPECIAL ANGLE CONNECTION FOR SHORT VALLEYS.

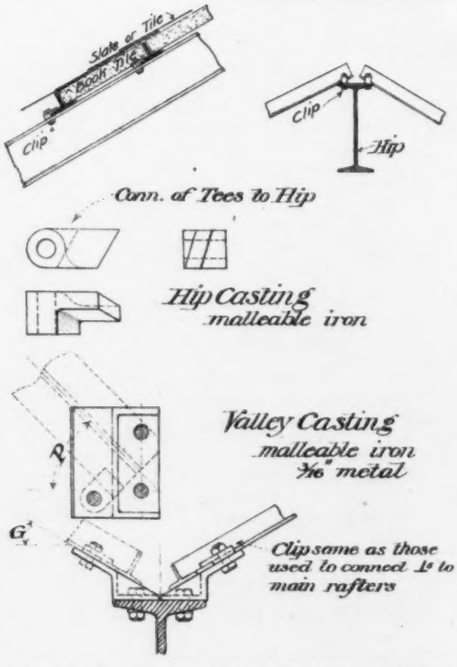

FIG. 18. CLIP CONNECTIONS FOR TEE PURLINS.

COMPUTATION OF

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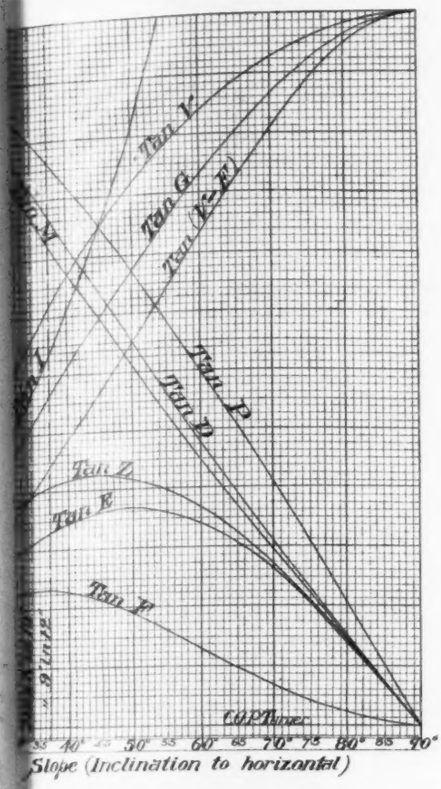


DETERMINING TANGENTS OF BEVEL ANGLES
MAL PURLIN CONNECTIONS.

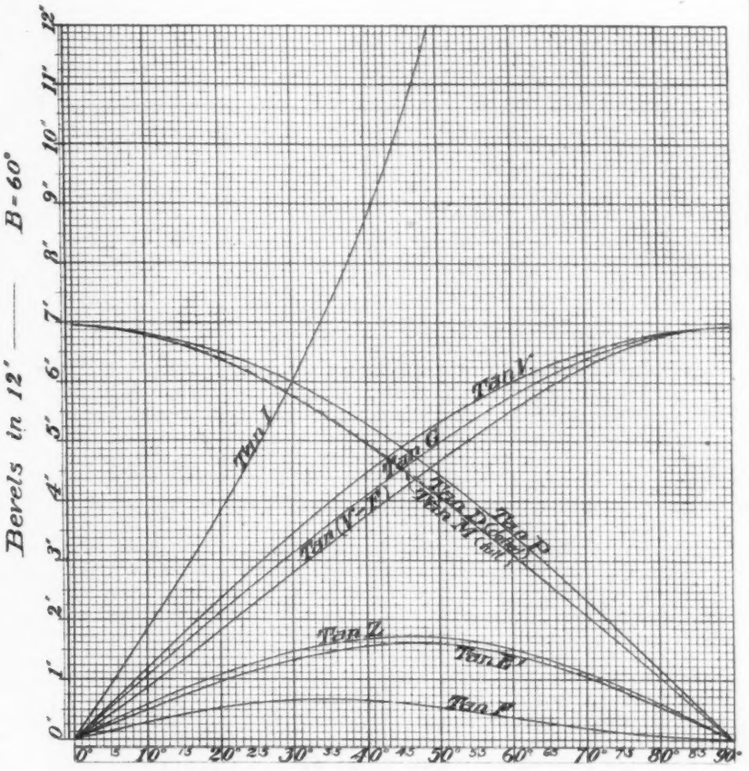
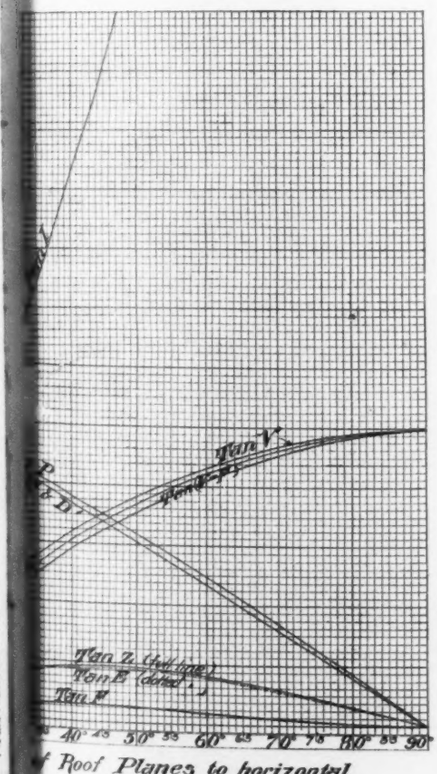


FIG. 13. DIAGRAM FOR DETERMINING BEVEL ANGLES
FOR NORMAL PURLINS IN HEXAGONAL TURRET ROOFS.



FOR DETERMINING BEVEL ANGLES
LINS IN OCTAGONAL TURRET ROOFS.

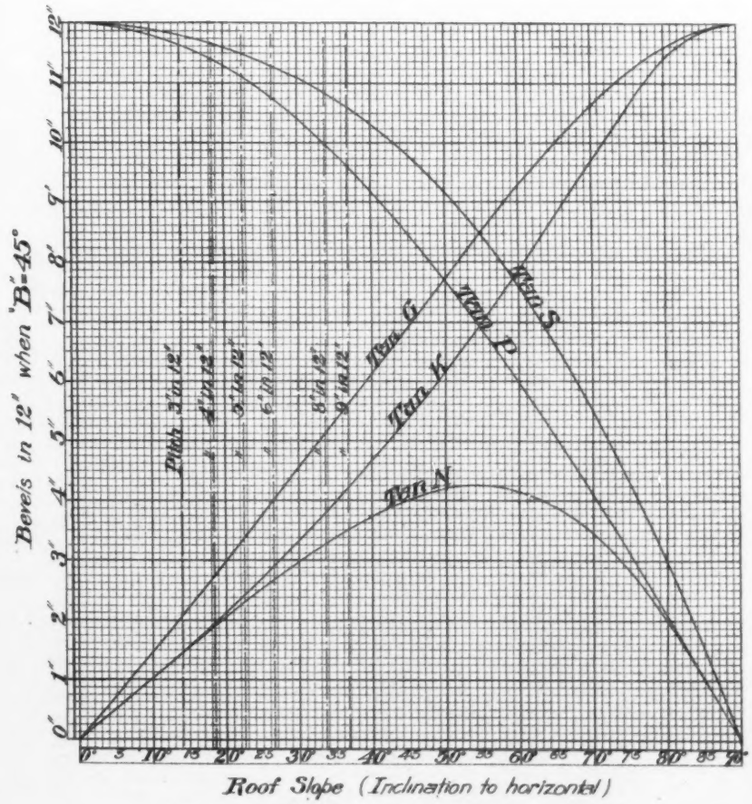


FIG. 15. DIAGRAM FOR DETERMINING BEVEL ANGLES
FOR JACK RAFTER CONNECTIONS.

OR ROOF WORK.

CHAS. HART, LITH., 30 VESEY ST., N. Y.

then a 0.25% carbon steel will withstand about 200,000; a 0.5% carbon steel about 400,000, and a 0.2% carbon and 5% nickel steel will withstand about 1,000,000 flexures. The enormously greater ability of nickel steel to resist fatigue as shown by these last figures is the property which most emphatically distinguishes it from simple steel.

Turning now to the influence of the nickel alloy upon the elastic limit and ultimate strength of steel we find it somewhat more difficult to draw accurate comparisons. The percentage of carbon present and the character of both the mechanical and heat treatment have so great an influence upon these properties in steel that it is unusually difficult to obtain identical conditions, except, of course, in the percentage of nickel. Furthermore, the effect of the nickel varies with the percentage of carbon present in the steel. Its addition always increases both the elastic limit and the ultimate strength, but the proportion of increase is greater with steels high in carbon than with those low in this element. A few figures selected from different sources by Mr. Browne and rearranged here in more convenient form for comparison, will serve better than general statements to show the effect of a nickel alloy upon the elastic limit and ultimate strength of steel. These figures are in all cases the results of actual tests of the material. It will be noted particularly that those furnished by the Bethlehem Iron Co. show that in a 0.2% carbon steel the gain in elastic limit due to 1% of nickel is 5,714 lbs., while in a 0.5% carbon steel it is 10,570 lbs. Tests made by other experimenters give other values, but they all bear out the general truth of the statement made above:

Table Showing Increase in Pounds per Square Inch Due to Addition of 1% Nickel to Steel.

Tests made by:	P.c. carbon.	Elastic limit.	Ult. strength.
Canadian Copper Co	0.1	4,384	3,814
Pope Tube Works.	0.25	4,000	5,000
Mr. Allen, Glasgow	0.14	5,485	3,500
Bethlehem Iron Co.....	0.2	5,714	8,571
" "	0.5	10,570	8,571
Crescent Steel Co	1.1	18,597	20,484

The particularly remarkable feature of this increase in ultimate strength and elastic limit due to the addition of nickel is that it does not materially reduce the ductility of the steel. When compared with simple steels of the same percentage of carbon nickel steel shows a slight decrease in elongation and contraction of area, but when compared with simple steels of the same strength and elastic limit it shows an increase in both of these properties. Mr. Browne considers that as a rule a 3% nickel steel will have from 20% to 30% greater elongation than a simple steel of the same tensile strength, while as compared with a simple steel of the same carbon percentage the nickel steel will have about 40% greater tensile strength and practically the same elongation and reduction of area. Besides adding to its ductility the use of nickel alloy with steel materially increases its ratio of elastic limit to ultimate strength.

When tested by impact for flexure, nickel steel shows greater stiffness and greater toughness than simple steel, the ratio of increase with 3% nickel steel being, respectively, about 48% and 45%. Its resistance to compression increases directly with the percentage of nickel up to 16%, when, according to tests made by Mr. R. A. Hadfield and quoted by Mr. Browne the samples showed a shortening of only 1% under 100 tons pressure as compared with a shortening of 50% exhibited by simple steel. Like its compressive strength the shearing strength of nickel steel increases directly with the proportion of nickel up to 16%, when it is about one-third greater than that of simple steel. The loss of strength by punching nickel steel is not greater apparently than that of mild boiler steel. Steel which contains over 3% of nickel is very difficult to weld. The mechanical working, that is rolling, hammering, etc., of nickel steel materially increases its strength and ductility. One of the most notable properties of nickel steel, however, is its great increase in elastic limit and ultimate strength due to quenching. Its great sensitiveness to heat treatment places the proper annealing temperature for nickel steel considerably below that required for simple steel. In proportion to its elastic and tensile strength nickel steel is softer than ordinary carbon steel, and its density is about the same for small percentages of alloy. Nickel steel suffers less from corrosion than ordinary steel, the difference being very slight for the regular 3% to 3½% nickel steels and increasing up to 18% nickel steel which is practically non-corrodible. All nickel steels have a high electrical resistance, the resistance of from 25% to 30% nickel steel being about 48 times that of copper. The coefficient of expansion varies between wide limits depending upon the percentage of the alloy.

This preceding enumeration of the chief properties of nickel steel, which is necessarily very much condensed as compared with their statement in the paper, bears out fully, it seems to us, Mr. Browne's assertion that it is a metal of remarkable characteristics. Of the various properties mentioned, it is evident that the increased capacity to do work due to its resistance to molecular fatigue is of the most importance to the mechanical engineer. Stated plainly the engineer has in the ordinary 0.2% to 0.4% carbon and 3% to 5% nickel steel, a metal with all the ductility of a low carbon steel and at the same time the strength and stiffness of a high carbon steel. These qualities suggest at once the utility of nickel steel for purposes where a decrease in the weight and dimensions of the component members is desirable in connection with the ability to endure heavy and continuous work. Shafting, piston rods, crank pins and the like are good examples of such members, and it is for them that nickel steel is principally employed, excepting always armor plate of course. At this point a few words may well be said toward setting aright the quite common impression that the extra cost of nickel steel of necessity precludes its use for other purposes than high-priced special forgings of the character mentioned.

Allowing a price of 35 cts. per lb. for nickel, the usual addition of 3% of that metal to steel increases the cost of the raw material about one cent per pound or $20 per ton, according to Mr. Browne's calculations. After the nickel steel is once in ingot form it costs no more to work it than it does ordinary carbon steel. The question then is, does this increase of cost of $20 per ton count nickel steel out of consideration for the more ordinary structural purposes where rolled plates and shapes are employed? Let us see, for example, how this question will be answered in bridge work, which is one of the most important engineering uses of steel. In bridge material high elastic strength is held paramount to greater tensile strength accompanied by a lower elastic limit. Opposed to this there is the equal necessity that the material shall have a high degree of ductility or toughness to withstand the impact shock of rolling loads. In the combination of these two qualities nickel steel possesses, as has already been pointed out, a marked superiority over carbon steel. If the two metals were equally available at the same price there would not, we think, be much doubt that the bridge engineer would always select the nickel steel for his work. With the difference in cost which actually exists the problem is more difficult to settle. It resolves itself into the question whether the superiority in the working strength of the nickel steel will allow members made of it to be constructed with enough smaller section to make up in reduced weight for more than the extra cost of the nickel steel. If this cannot be accomplished there is obviously little use in considering the general substitution of nickel steel for bridge work, and this is evidently a question which will need more data to settle conclusively than we have at present.

There is, however, still another feature of this subject. If it should be settled that the use of nickel steel throughout is undesirable, is it not quite possible that it may be substituted with advantage in place of the commonly used hard and medium carbon steels for certain members. The severe duties of bridge eye bars, for example, have led in some recent instances to the use of simple steel having as high as 0.4% of carbon in order to get the necessary high elastic limit. In this manner the engineer gained his immediate object, but he did it at a loss in the ductility of his members and at the danger of deterioration in manufacture. The thing which it is chiefly important to point out, however, is that the same high elastic limit can be obtained by using nickel steel and still retain all the ductility of a steel low in carbon. These few remarks are necessarily incomplete, but they indicate, we think, that the possible use of nickel steel for bridge and structural steel work is by no means one which can be ruled out of consideration by engineers, without careful investigation.

Turning now to the other remaining extensive use of nickel steel in plates for boiler and tank work and for ship's hulls, Mr. Browne points out that in some respects this material presents even greater claims for consideration than it does in bridge and general structural work. No less an authority than Sir William Henry White, Director of Naval Construction of the British Navy, has said that by using nickel steel in an Atlantic liner of 20 knots speed, about 1,000 tons in weight could be saved, which could be used in increased capacity for freight, or which would suffice to raise the speed one knot without altering dimensions. In warships this reduction of the dead load would be of even greater importance by adding to the coal capacity and the weight available for armor and armament. The fact that the loss by corrision of nickel steel exposed to salt water is much less than that of carbon steel constitutes another element of especial fitness for hull plates. The experience with nickel steel for boiler plates is limited, but its suitability for this purpose seems evident. Its greater elastic and tensile strength and far greater ductility in proportion to its strength suggests its special fitness to meet the increasing pressures, greater strength and more severe duties which are now being required of steam boilers, especially for use on shipboard.

So far we have been chiefly engaged in pointing out some of the possible fields of utility for nickel steel. To catalogue the uses to which the new alloy has already been put with greater or less success would take more space than can conveniently be given in these columns, but a brief review of a few of them is desirable.

As a material for armor plates the nickel steel alloy has proved its advantages beyond question, and nickel steel armor-plate is now employed by all the naval powers. It has gained an almost equally permanent standing for the construction of shafting and engine forgings for warships and for the more costly vessels of the mercantile marine. The principal reason for this popularity of nickel steel in marine engine forgings is, of course, the great reduction in weight which it affords as compared with simple steel of the same strength. For example, the hollow nickel steel propeller shaft of the U. S. S. "Brooklyn" has a diameter of 17 1-5 ins., and weighs 19,112 lbs. According to calculations made by Mr. H. F. J. Porter, M. Am. Soc. M. E., a solid simple steel shaft of the same strength would be 18.9 ins. in diameter and would weigh 53% more. Another advantage of nickel steel for marine engine construction is its greater safety owing to the warning which it always gives of failure.

The same characteristics which make nickel steel shafting and forgings superior to ordinary carbon steel in the engine room of a warship suggest their utility for other purposes where the requirements are similar, and it is natural to find that this material is winning its way in the field of railway mechanical engineering. In some respects this is a more promising field of usefulness than that of naval construction. It is, however, one which is controlled by more conservatism and particularly by a greater need of making every item of extra expenditure pay for itself in increased durability and efficiency. For such purposes as locomotive piston rods, crank pins, etc., nickel steel has already gained a firm footing in the mechanical departments of American railways. In England tests made on nickel steel driving wheel tires have shown that they possess a material superiority over the low carbon steel tires commonly employed in that country. The usual English specifications require that railway tires shall stand compression one-sixth of their diameter without cracking. Actual tests made on 39½-in. tires of 0.18 carbon and 3% nickel steel are given by Mr. Browne, which show that the tire was compressed to 19 ins., or more than three times what the specifications required, without showing signs of fracture. Tests of the steel axles of which 600 were supplied for the 100,000-

lb. ore cars of the Pittsburg, Bessemer & Lake Erie R. R., showed that axles of 0.25% carbon and 3% to 3½% nickel steel were as stiff under impact as ordinary steel of 0.4% to 0.45% carbon and would withstand 50% more blows. In every case the nickel steel axles gave warning of failure while the common steel broke short without warning.

Among the miscellaneous or special uses to which Mr. Browne mentions nickel steel alloys as being applied are resistance wire, bicycle tubing and spokes, staybolts, fire-box sheets, boiler tubing, firearms, safes and vaults, bobbin-spindles, and a great variety of other purposes for which some peculiarity either of strength, ductility or incorrodibility gives it special fitness. One of the most promising of these uses for nickel steel is the making of tool steel of it. Extensive experiments in this direction have been made by the Damascus Steel Co., of Pittsburg, Pa., and they are of so interesting a character that we quote the results given by Mr. H. J. Williams of that company to Mr. Browne, as follows:

Sound billets of nickel-steel of any desired percentage in nickel or carbon can now be obtained. The working of these billets into tools or wire-rods presents no especial difficulties. The nickel-steel works tougher than simple steel; causes more rebound of the hammer and necessitates a lighter draft on the rolls or dies.

For tools, the alloy containing about 0.80% carbon, with 3% of nickel, is probably the best alloy for every-day use. Increasing the nickel to 5 or 6% increases the strength, but necessitates skilled treatment in forging. Tool-steel with 0.80% carbon and from 3 to 5% nickel, possesses all the hardness of high-carbon simple steel, without its brittleness. Nickel-steel shows very pronounced toughness. If nicked when hot, and then struck on the anvil after it has cooled, it is very liable to break under the hammer—not at, but beyond the nick; while carbon-steel almost invariably breaks at the point where it was nicked when hot. This nickel tool-steel has a satin grain and does not crack on quenching as readily as simple steel; the tensile strength runs as high as 200,000 lbs. per sq. in. A nickel-steel tool containing 4 or 5% of nickel, with 0.80% carbon, is as hard after tempering as the best simple tool-steel of 1.00 to 1.25% carbon, without the brittleness and glassy nature which distinguish the latter. When used for drills, the nickel-steel appears to work with much less than the usual friction, and does not become so hot in use as carbon-steel.

Up to 6% of nickel, the hardness obtained by quenching is as largely dependent on the amount of carbon present as in simple steels, the only difference being that nickel-steels appear to attain a desired temper with 0.20 to 0.30% less carbon than simple steels. Nickel-steels are consequently exceedingly sensitive to heat-treatment, but, on the other hand, are less easily spoiled by overheating, and threfore may be worked at somewhat higher heat than a carbon-steel that will give the same temper.

While the list of uses for nickel steel which have been mentioned is necessarily far from being exhaustive it shows clearly, we think, that there is a very wide field for its employment by the engineer. The fact that only about 10,000 tons of nickel steel were produced in the United States in 1899 for other purposes than armor plate also indicates, we think, that engineers have only just begun to wake up to the fact that they possess in this new alloy a remarkable metal for high grade machine and structural work. This is a condition which we may expect to see remedied, but there is another difficulty in the way of the more universal use of nickel steel which would be otherwise possible, which is the limited amount of available nickel.

At the present time there are only two regions in the world which produce nickel in any quantities and their output is not large and does not show any signs of being capable of a notable increase. It is not well known, even, so far as we have been able to discover, just what the extent of these mines is, and whether they are capable of indefinite expansion or are likely to be soon worked out. One thing we do know, and that is that the increased demands for nickel in 1899 raised the price about five cents per pound with the prospect in view of further advances during the present year. It needs no great argument to demonstrate that this will cut short the demand for steel making, which might otherwise be expected during 1900. All things considered, then, it seems that the greatest bar to the increased employment of nickel steel by engineers beyond a few important purposes where great quantities are not required and where cost does not count, is the questionable ability of our present mines to produce the requisite supply of nickel at reasonable prices.

A SUBWAY FOR ELECTRIC CARS under the crowded portion of Fulton St., in Brooklyn, N. Y., is being discussed by prominent business men of that city. The congestion of traffic here is due to the electric surface cars which pass over the Brooklyn Bridge.

LETTERS TO THE EDITOR.

Graphical Diagrams for Straight Line Compression Formulas.

Sir: In your issue of Jan. 25, 1900, you publish a diagram of straight-line compression formulæ supplied by Mr. O. W. Childs. Allow me to state that the same idea, worked out in somewhat more extended form, was supplied by the writer and published in your journal in the issue of Sept. 22, 1898. Yours truly,

Jno. S. Fielding.

913 Rebecca Ave., Wilkinsburg, Pa., Feb. 7, 1900.

Driving Water-Wheels from Steam Pumps.

Sir: Regarding the Columbus electric lighting plant installed in part by us and described in Engineering News for Dec. 28, 1899, we have recently received a letter from a friend in California which puts the matter in another light, and which may be of some interest to your readers. Our correspondent says:

I am operating a high-duty pumping engine to pump water for driving a number of elevators. When the elevators all stop, which happens quite frequently during the day, an overflow valve opens from the excess pressure and the water wastes back into the suction or surge tank. Now, I expect to use this water in an impulse wheel driving a small dynamo to furnish about 75 lights for use in the engine room and elsewhere. As the overflow would not be constant, the wheel will be fed directly from the tank, which gives a constant pressure of about 125 lbs., and I think the outflow of water will always be sufficient to prevent the pumping engine from stopping on centers.

It will be seen from the above extract that the idea of supplying water-wheels from high-service pumps is not always so unpractical as it may at first appear. There are, also, advantages in the way of convenience and freedom from noise and vibration, which we could illustrate by other examples.

American Impulse Wheel Co.,

120 Liberty St., New York city, Jan. 20, 1900.

A Tough Engineer.

Sir: In some manner the clothing of the engineer at the Olympic Iron Works of this city was caught in the revolving shaft of the engine and his body instantly was drawn in and began whirling with the machinery. After a short time (variously estimated at from one to five minutes), the engine was stopped and the apparently lifeless body was taken down, practically denuded of clothes and bleeding from many wounds on the face and other parts of the body. Almost immediately signs of recovery were shown, and before an ambulance arrived the man was able to sit up and even to walk, with assistance.

The remarkable feature of the accident lies in the fact that the man was whirled around with sufficient speed and force for his feet and legs to strike the floor and split 1-in. boards, without breaking any bones or even badly straining or bruising them. As the shaft was revolving over 100 revolutions per minute, and the distance from floor to shaft is about 3 ft., his feet were traversing the circumference of a circle 6 ft. in diameter at a velocity of approximately 2,000 ft. per minute.

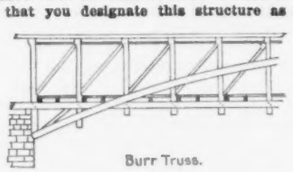
We are all familiar with the phenomenon of shooting a candle through a board without damage to the candle, but that a human being can be caught by the shoulders and made to split kindlings with his heels without damage to the aforesaid heels seems well nigh incredible.

Yours very truly, A. McL. Hawks.

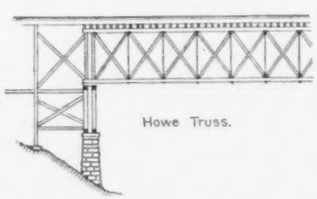
Tacoma, Wash., Feb. 6, 1900.

The Zanesville, O., Timber Truss Y-Bridge.

Sir: I am much interested in the account of the Zanesville, O., timber Y-bridge, published in your issue of Jan. 25, 1900. For the sake of literal historical accuracy, I regret that you designate this structure as a timber



Burr Truss.



Howe Truss.

Howe truss. I am not familiar with the bridge in question, but judging from the date of its erection, 1831, I would venture the assertion that it is a Burr truss, a style of bridge invented by Theodore Burr in the early part of this century. At one time there were many notable examples of this style of bridge in existence. The bridge at Waterford, N. Y., built in 1804, with four spans, respectively 154, 161, 176 and 180 in the clear, was of this type. I believe it was standing only a few years ago.

It is not probable that the bridge is a Long truss, a modification of the Burr truss, invented by Col. S. H. Long, of the U. S. Engineers, in the year 1830.

The Howe truss was not patented until 1840 by its inventor, William Howe. Yours truly,

Buffalo, N. Y., Feb. 2, 1900. W. O. Lellme.

(A proof of this letter was submitted to the Osborn Co., of Cleveland, O., whose report was our authority for stating that the bridge was of the Howe truss type, and they send us the following reply.—Ed.)

Sir: Answering your letter of Feb. 5, inquiring for the facts concerning the style of truss of the old "Y Bridge" in Zanesville, we would state that your correspondent is correct. We have already answered one inquiry of this nature. The truss is, correctly speaking, a Burr truss. The name of Howe truss was applied to it under a very common mistake, using the term carelessly to indicate any truss the web members of which are composed of diagonals in compression and verticals in tension, as opposed to the Pratt truss form, in which the respective stresses are reversed. This bridge was built by Mr Buckingham in 1831-2, and the form of truss used by him was known in that locality as the Buckingham Bridge. This was only a local term however. Thanking you for your courtesy in referring the matter to us, we are,

Yours truly,

The Osborn Co., Civil Engineers.

Bernard L. Green.

Cleveland, O., Feb. 8, 1900.

Broken Stone vs. Gravel Concrete.

Sir: In reply to the letter of Prof. Ira A. Baker, published in your issue of Feb. 1, 1900, I may say that I have had several years' experience in the concrete business, and have had occasion to use large quantities of gravel or pebbles taken from along the shores of creeks and small streams, for making concrete. My first experience was about ten years ago, when I was called upon to finish a piece of work where the concrete was made of Hoffman rosendale cement and gravel. The next year the same person had me put down a front pavement, and I used Portland cement, sharp sand and broken stone 1½-in. size. About two years afterwards he called on me again to make some alterations, and in carrying them out I had to cut through concrete of both gravel and broken stone. I found it much harder to cut through the gravel concrete than it was to cut through the broken stone. I also found that the gravel contained fewer voids and was more compact than the broken stone. In breaking the gravel concrete the pebbles would break in two parts, but the broken stone would tear away and leave the remaining part whole. At present I am using large quantities of gravel taken from the Delaware River bed. It is good, clean, coarse gravel, and we find that it gives better results than broken stone and sharp sand. Our work contains fewer voids and I can safely say, from actual experience, that for strength a good, clean gravel concrete will surpass one of sharp sand and broken stone, and will contain fewer voids. Yours truly,

W. B. Pine.

Camden, N. J., Feb. 3, 1900.

Sir: Referring to the matter of stone vs. gravel concrete, I wish to touch on their relative merits from a practical standpoint, and not from any laboratory test. In comparing the two we must limit ourselves to similar sizes, as 2-in. stone and 2-in. gravel. In my experience I have found that in using gravel and stone of similar sizes, the latter is preferable. I may mention first one instance, where tension and compression are both conspicuous at the same moment, and the relative merits of the two materials are well compared. This occurred in the construction of an underground conduit system of a street railway company in New York city. Broken stone, 1½-in. ring size was generally used in the U-shaped concrete conduit forms, but at times gravel was substituted for stone when the latter was temporarily exhausted. Some four weeks or more after the concrete forms were removed, and the track open to the public, the portions made of gravel concrete simply collapsed, owing to the vibrations of heavy loads passing over running rails and slot rails, while those made of stone concrete remained intact.

In ramming gravel concrete, especially that of the pea size, the water in the voids will follow the smooth, round surfaces, thus separating each pebble from the mortar and leaving a perceptible film of almost clear water around it. In stone this does not occur to any extent, because of the rough surfaces, and unequal sizes and shapes that passed through the same sized ring. Another argument against the use of gravel, is that owing to its uniformity of size, it can be rammed so that each pebble is almost in contact with those adjoining, thus preventing an equal distribution of the mortar through the voids. My opinion is that if different sizes of gravel were used, in the mixing, that it would be equivalent to, if not better, than stone concrete of one size broken stone. When the stone used

is broken in different sizes, from screenings to 3-in. size, there is nothing so good.

Edgar M. Smith, Civil Engineer.

261 Commercial St., Boston, Mass., Feb. 6, 1900.

An Alleged Electrical Gas Process.

Sir: In Engineering News of Dec. 7, 1899, was published an article entitled "An Alleged Electrical Gas Process," containing references to myself and to my work which I conceive do me a serious injustice. As soon as possible after the publication of this article I prepared an answer, somewhat in extenso, going into details sufficiently to corroborate my statements, and to disprove the misstatements in the article. On submitting this answer to you, however, you found that it would occupy more space than you could conveniently spare, but you very kindly and promptly said, you desired to give me ample opportunity to reply, and if I would give you an abridged reply, you would publish it in your next issue, the policy of your journal being to be fair to everyone, and to oppress none. I, therefore, have the pleasure of handing you this letter, replying more briefly to the article published, as follows:

(1) The Equitable Gas Light Co., of San Francisco (owner of the "new gas process" in that city), has been supplying fuel gas, for light, heat and power, for over ten months past, and is selling gas there at 65 cts. per 1,000 cu. ft., as against $1.50 per 1,000 cu. ft. charged by the old companies.

(2) The Passaic Equitable Gas Co., organized under the laws of the state of New Jersey, offered the people of Passaic, N. J., gas, for all purposes of light, heat and power, at 50 cts. per 1,000 cu. ft., and asked for a franchise, giving permission to lay its gas mains, and supply consumers, the franchise being made forfeitable if the price charged by it for gas ever exceeded 50 cts. per 1,000 ft.

The people of Passaic had abundant and satisfactory testimony given them, from consumers and others, as to the excellence and economy of the 50-ct. gas they were offered, as a permanent institution. They were very enthusiastic in their reception of the offer, and at a large special meeting of the Board of Trade that body voted unanimously a request to the City Council to grant the new company the franchise it required. The Special Committee of the City Council also reported unanimously in its favor, and it is now taking its regular course.

The article starts with an erroneous statement. There was no "Thurston G. Hall process," patented ten years ago, as it states there was. Again, Hall's process was not alleged to convert a weak water gas to a gas of high heating and illuminating power. Again, the process was not "revived in 1898 in San Francisco by Dr. J. W. Chisholm." Again, there is not, and cannot be, any dispute between persons who know anything about it, as to the fact that the "Oakland Equitable Gas Co. is building a gas plant at Oakland." The plant is there, almost finished, large and handsome, "plainly to be seen of all observers." On 67th line, 2d column, the article should read: "In order to save their patrons" (not patents). This refers to the "Gas Journals."

Referring to the statement near the middle of the third column, Dr. Chisholm never said: "The nitrogen the gas contains is not the ordinary atmospheric nitrogen." Dr. Chisholm would not say anything so ridiculous.

The statement that "any man who sets up claims that are contrary to established and universally accepted scientific facts, and who refuses to submit these claims to the tests and measurements in common use by scientific men, brands himself at once as a fraud," is misleading and unscientific. There are many scientific hypotheses now accepted, the discoverers of which were forced to set up claims that are contrary to what were then "universally accepted scientific facts," and who had to refuse to submit their claims to unsuitable tests and measurements, namely, "tests in common use."

Gas lighting, by the incandescence of a mantle, or web of rare or other metals or earths, was the outcome of empirical research, and was not the fruit of a consistent application of previously ascertained fundamental principles of physics. Is the Welsbach light, with its inestimably valuable and beneficent results, to be thrown away and rejected because it was not the fruit of persistent application of previously known "scientific facts?" The action of the mantle cannot yet be explained by any of the tests or measures in common use by scientific men, therefore, according to the article, it is a fraud. On the other hand, true scientists and all practical men should gladly accept results.

This new gas process may not be the result of previously known scientific facts. It may not be measured by gas scientists' tests and measures for the gas of other days; these devices having been haltingly and with many delays and errors invented to test and measure their products of the past; instruments, too, confessedly fallible, which have had to be changed and improved from time to time (until set aside altogether), as their inaccuracy and unsuitableness, in some one point or another, had been demonstrated.

The old gas companies, making "Lowe gas" and coal gas, claim to have 600, 650 or 700 (theoretical) heat units per cubic foot; that is, heat units by calculation, obtained by tests and measurements in common use in the laboratory, and which are deceptive, a mockery, a delusion and a snare; so far, at least, as the consumer is concerned. The poor fellow never gets these heat units except on paper, as the same gas, in a practical, commercial test, such as raising a given quantity of water from a stated temperature to boiling point, only gives, under test by observation, about 340 H. U. In practice, it was found that taking twenty of the largest and best gas companies, in the largest cities of the country, their average heat units, taken by observation (not theoretical calculation), all by the same apparatus, and the same quantity of water, for purposes of comparison with the before mentioned phenomally low cost gas, proved that their heat units were not really 600 to 700, as they falsely pretended they were, but they ran at 284, 350, 367, 320, 332, and so on. The average of the twenty companies (including some excellent coal gas) was 344 heat units; while the average of the low cost gas was 336, or only about 2% less than the expensive gases; although it was made under specially great disadvantages.

As to the quotation from Dr. Henry Morton, I judge from the quotation, as published in your journal, that the matter has been put before the doctor in a partial or imperfect way, and I feel sure that if he knew all the facts his opinion must necessarily be a different one. Dr. Morton's ability and fairness are well known, but, like all other human beings, he requires the facts to be fully placed before him.

Further quotations are made, first, from the "American Gas Light Journal" and from the "Progressive Age."

I will state for the enlightenment of your readers, that I have frequently given both of these journals opportunity to publish facts respecting progress in manufacturing cheap gas, but never has anything true been published by them, respecting the "new process" for "fuel gas," or any fact, or news, given to their readers, that would enlighten them, or make them aware of the progress made in the art. There is nothing that is true stated in any of the quotations from the "American Gas Light Journal," or "Progressive Age," which affects me in any way.

Concerning the "Proctor process," I have never had anything to do with it, and do not know what it was. In fact, I have never been in the place where it was said to have originated or been used.

All I would say in this letter respecting Mr. Sprout is, that I met the gentleman nearly two years ago in the East, before I went to San Francisco, and he told me he was a "contractor for building small electric plants," and asked for an opportunity to bid on the gas plant I was about to build. A very few months after the appearance of Mr. Sprout's letter, the owner of the "Journal of Electricity" had the matter brought to his attention, made careful investigation into the new gas process, and its results, after which he came to me and very handsomely offered the use of the columns of his journal to make what amends he could.

In introducing Mr. Jones' letter your article says:

> Finally, we have a luminous exposition of the operations of Dr. Chisholm and his associates in San Francisco, which we have received from Mr. E. C. Jones, Engineer of the San Francisco Gas & Electric Co., of San Francisco, and we print it in full.

Your article, therefore, not only attacks the process and me personally, but attacks my associates, and the "operations of myself and associates" in San Francisco. The gentlemen who were my associates in San Francisco are very well known. They consist of merchants, lawyers, shipowners, honest men, who have taken up an honest enterprise, and in an honest way, carrying out in letter and spirit every promise made to the public, and to each other; even under tremendous strain, much persecution and an amount of misrepresentation by the old companies and their satellites that might be termed phenomenal, they have perseveringly carried on a new and most valuable enterprise to a successful issue.

In all their struggles with the big gas companies and their unscrupulous methods, they have never once departed from the straight lines of honest procedure and respectable business methods. They have put in their money, their time, and much hard work to supply San Francisco with economical fuel, and light, and I have never met men associated together, in a new bitterly antagonized business enterprise, more worthy of praise.

In Passaic, Mr. Andrew McLean, a leading and very prominent citizen (twice mayor of the city), represents the gas company asking a franchise for supplying 50-ct. gas. His high character for honorable dealing, and his unvarying success, not only at Passaic, but elsewhere, are guarantees of a vigorous and successful prosecution of this, his pet enterprise.

For over two years, Mr. McLean has been watching this new process, anxious to give the city of Passaic the benefit of cheap "fuel gas"; and with the carefulness and conservatism for which he is known, he has examined into the whole matter most thoroughly and in detail, having gone personally to San Francisco and examined the new gas works, when nearly completed; since which time, he has had his confidential agents several times in San Francisco, examining into the process of manufacture of the product, the lighting and heating as seen in hundreds of stores and dwellings, has had hundreds of consumers questioned closely, as to the quality of the light and heat and its economy. The burden of the reports which he has got is that the light is better and the heat greater than that of the old company's gas, and the customers say that the savings on their old bills range from 30 to 60%. Mr. McLean and his friends are risking both money and reputation, and he took great care to get actual, positive and reliable information. He has got that, is satisfied, and is backing the enterprise in Passaic.

We now come to Mr. Jones' letter. Mr. Jones had abundant opportunity, on Dec. 21, 1898, to learn something about the new gas process and apparatus. He visited the works of the Equitable Gas Light Co. on that day, and was received there by me. He witnessed the whole process of manufacturing fuel gas, saw the material put into the generator, the gas made, and stored in the gas holders. He saw it burned in cooking stoves, heaters, and numbers of lamps. He also saw it used in gas engines, generating electricity, and running numerous electric lights. Details of the manufacture were carefully and patiently explained to him; his questions were all frankly and fully answered, and at his request a sample of the pyro-electric cells given to him. After all he saw, and the full explanation given him of a very simple process, Mr. Jones seemed to go away as ignorant as he was when he came, and his letter confirms the conviction that he knows nothing whatever about either process or plant.

He starts his letter with a very inexpert blunder. He says:

> The company proceeded to construct a small gas works on the Hall system, consisting of a generator of the ordinary cupola type, with a take-off pipe half way up the generator, while the remaining top section is of no use whatever.

Mr. Jones did not know that the "poker" (so-called) could not be used without that top section. It consists of a heavy weight attached to a chain, with proper drum and other mechanism for winding it up after each descent, and which is placed in the upper part of that top section. He evidently does not know that the weight mentioned requires a space to fall through, or a certain height from which to descend, in order to do its work, which is to break down frequently the crust or cake formed in the burning coal within the furnace, and thus prevent the formation of passages in the firebed, by which free oxygen could get admission to the chambers of the electric regenerator, and that this space or height is furnished by the top section.

Can Mr. Jones inform us how the said apparatus, with its water-jackets, etc., can be as well protected from the heat of the furnace as by the use of the top section which he pronounces of no use whatever?

"The Regenerator (or Thermo-Electric Chamber).—Mr Jones describes what he calls the electric chamber, as "a large coffin-shaped superheater!!" Again he is wrong. Surely he should be able to discriminate between a construction of elliptical form, with its curves, and a coffin-shaped structure.

From paragraph 3 to 12, Mr. Jones attempts to say something about the cells of the regenerator, but shows he is so ignorant regarding them, that he cannot even give them the same name twice. In one paragraph he calls them by three different names, viz.: "Electric batteries," "galvanic pile batteries," and further on, "electric chambers." Again, he calls it, "the worst kind of a superheater, filled with a lot of flower-pots." All this is not only very inaccurate, but it is silly nonsense, not worthy to be considered by business men, or published in a high-class technical journal.

Mr. Jones says that "this electric chamber contains no electricity." How does he know? Did he ever try? If so, where, when and how? If he did not try, and does not know, is not his statement reckless, at least? Is it not wrong to make a damaging statement about a thing he does not know, never tried, and does not understand?

He next makes the following statement:

> The batteries themselves did not constitute a galvanic pile, as the metals are not in contact, and the first dash of tar and oil from the generator would completely coat every part of the metal and the crucibles in which they were contained, and the succeeding blast would bake this tar into a cake of carbon, thus the most expensive part of the Hall process, and the part for which the most was claimed was inoperative from the first, and its failure to work became evident to the men who ran the works.

As there is not one word of truth in the statements quoted from Mr. Jones' letter, there is no use in characterizing them. The "regenerator" structure contains a battery consisting of about 6,000 cells, but there is no need for the batteries (as he calls them) to "constitute a galvanic pile." Why should they? A galvanic pile would be very much out of place there. Mr. Jones does not know that the "dash of tar and oil," the cooking and the baking and the cake, and the "failure to work," are all figments of his imagination. The dash of tar and oil is not possible, neither are the others. He does not understand the construction of the regenerator, nor the precautions taken to guard against even the light ashes and dust being carried over into the electric chambers, or he would not expose his ignorance of the matter, as he does, in the foregoing statements. What Mr. Jones asserts has never

taken place. If it had, the plant could not run one day, whereas, it is running and has been running faithfully and reliably every day for over a year, and sending out lots of good gas. As to the cells (or crucibles), they can be seen every day through openings made for the purpose, in the side of the generator, and their condition has invariably been, to use the words of the officer in charge, "as clean as a hound's tooth."

Regarding "failure to work," I received a letter from San Francisco a few days ago which says: "We made this morning 300,000 ft. in 1½ hours, and the machine 'was in perfect shape' at the close. The gas was good, and we wasted no oil." (This was the morning run.) "The machine is in perfect shape," after running every day for over a year. How, then, should statements like those of Mr. Jones' be characterized?

I would state here, that the thermo-electric battery referred to by Mr. Jones consists of about 6,000 cells filling the chambers of the "regenerator." The regeneration of the products of combustion, etc.,to produce fixed heating and illuminating gases by means of metals of opposite electric polarities is an entirely new thing, the effectiveness of which is practically demonstrated. We know what material we put into the generator, we know what comes out from it, we know its character and commercial value, as well as the character and commercial value of the material used. By what processes, or in what way, this regenerating device operates, it is impossible to say with confidence. It operates in a chamber, in the presence of the products of combustion, etc., and of high heat, and, as in other electrical devices and processes, all that anybody knows is the result. I state with absolute confidence, begotten of experience, and of practical demonstration and results, made on a large commercial scale, that there is no other kind of superheater, "regenerator," or converter, on the face of the earth, be it the "Lowe" process, or any other, which can do the work, or produce the results, that this thermo-electric battery can do, and has always done, when properly used.

Meters.—Mr. Jones says that "in the beginning, there were no meters."

In the beginning, there were some delays in getting material from the East to San Francisco, and during these few days' delay, people saw the beautiful lights our fuel gas gave in the principal streets of the city, and would not wait for the meters, then on the way. They pressed the company beyond measure to let them have the gas. The company arranged to let them have it for a short time, until the meters could be put in, and to charge them one-half the amount of their old gas bills until the meters were adjusted and placed. The customers were delighted with this arrangement, and the Equitable Gas Co. was satisfied. We not only use a meter with every customer, but our meters are adjusted to measure correctly, and our customers are satisfied that they are honestly treated.

Mains.—The mains of the Equitable Gas Co. are much larger, on the average more than double the size, of the San Francisco Gas & Electric Co.'s, because they are laid with the intention of supplying fuel gas, and selling many times the amount of gas ever sold by their competitors. They are better and more scientifically laid than the old company's with good tight joints.

Analysis.—Mr. Jones gives two of his analyses of the new gas, in his letter. It is absolutely unimportant whether they are correct or not. Practically, it has no bearing on the merit of the two gases. He wants analyses pertaining to illuminating gas. We make a fuel gas. The result obtained from the gas we make gives the kind of analysis satisfactory to the customer. Mr. Jones' mode of making gas gives a result, which, the customer says, is a dirty gas, with a poor light, very unsatisfactory, and costing twice as much as ours. How the gas is produced is a matter of little consequence to the public. They want light, heat, power, at reduced cost, and we give them.

Material Used.—Mr. Jones makes several statements of the material used in making the "new fuel gas," which argues his ignorance of the first principles of the process and apparatus. They are untrue and extravagant, but I will answer, for the sake of your readers. This new process is meant for making a "fuel gas only," not an illuminating gas. Its bright lights are derived from the use of its heat with incandescent burners, not from many gallons of oil, as in the Lowe process.

If we were to pour in illuminants in the extravagant way Mr. Jones states, it would not only be foolish, but wasteful. The process is not intended for much oil, neither is the plant. It would be a mistake of the worst kind, a complete wrenching away from the purpose of both, which is, to make "a gas of low candle power at low cost, with value sufficient for all cooking, heating and power purposes, and producing brilliant lights with the proper modern burners. The process is not intended for an "open tip gas," but for use with the incandescent burner, the best type of which is the "Welsbach burner." Fuel gas and the Welsbach burner go together, seem to be made for each other, and give, in company, the greatest and most economical results for lighting of anything in the world.

The brightest and most beautiful lights ever seen in San Francisco were our lights, first exhibited corner of Market and Stockton Sts. That gas was made with 2¾ gallons of Ventura oil, and 16 lbs. of coal, per 1,000 cu. ft. It was fuel gas, giving fine heat and splendid light. Some of the last runs I made personally, before coming East, showed a consumption (one on July 18) of 750 gallons of oil to 263,000 cu. ft. of gas made (or 2.8 gallons per 1,000), and (on Aug. 4) 270,000 cu. ft., made with 784 gallons of oil (or about 2.9 gallons per 1,000). Any attempt, however, to make "candle-power gas," or "open tip gas," with neither process nor apparatus intended for it, would be disastrous to quality, and to economy of manufacture, as the plant is built to make fuel gas.

Pressure.—"In the beginning," before the Equitable Gas Light Co. knew what pressure to use, in their gas mains, and while as yet they had no "governors," either for the mains, or on the meters, they made the mistake of having too great pressure. It was quickly remedied, and gradually brought down from nearly 6 ins. to 2½ ins. and less.

A Blunder.—In the 10th paragraph of his letter, Mr. Jones makes the following statement, which would greatly amaze the thousands of people in San Francisco using the Equitable Co.'s gas, as well as the thousands more who have seen it used, for many months past, and who all bear the highest testimony to its superior excellence and economy. Mr. Jones goes too far. He says: "(1) The gas was so poor it would not light on an open burner. (2) That it would not light on any of the ordinary 'Bunsen burners' of gas cooking or heating stoves. (3) That the gas is practically valueless for fuel purposes with ordinary gas appliances."

These are Mr. Jones' statements, while the facts are, that the gas has the best records for light and for heating purposes.

The people say: "I find Equitable gas as an illuminant and for cooking far superior to the San Francisco Co.'s gas."

Your Equitable Gas Co. furnishes a more satisfactory light with more heat than the San Francisco Co.'s at less than one-half the cost." "I am exceedingly well pleased with it for cooking, as it gives a much hotter gas than the old company's.

Tests.—Mr. Jones, in paragraph 11, mentions "daily tests" made in the secret laboratory. In answer, I will publish facts concerning tests made publicly:

In March, 1899, the Equitable Gas Co. had progressed so far as to have many services already in, and supplying customers with gas for light and heat, and had fully demonstrated its light, and its splendid heat, to thousands of people in the busiest streets in San Francisco, but it was in the midst of experiments on burners for lamps and stoves, on the pressure necessary to get good results, on sizes of holes in burners, and on different kinds of "governors," all necessary details of starting the use of a new gas, in a new place, and with new material, viz., the crude oils of the state, and the coals used in California, all being new to everyone connected with the company.

Among the first tests of the gas made, was one by Prof. Green, the city chemist, as to the percentage of the deadly poison, carbon monoxide, contained in each of the gases made in the city, with the following result: San Francisco Gas & Electric Co., 19.4% carbon monoxide; Pacific Gas Improvement Co., 22%; Equitable Gas Light Co., 6.22%.

The next test that was made, was for the purpose of determining the comparative quantity of gas used by the different companies in giving the ordinary Welsbach light in stores, etc. This test was made in the presence of Mayor Phelan, Supervisor Perrault, Supervisor Lackmen, Inspector Tupper, besides a number of other gentlemen.

The officers of the company and these gentlemen all went to the place of test, without any previous preparation, and used the lights just as they were being used by the consumers. In this test, in which the Equitable Gas Light Co. had no governors on their meters or mains, the pressure was very high.

There were six tests made. The Equitable Co. burned 4.6, 4.5, 4.5, and, on a single branch gasolier, 4.7 ft. of gas per hour, while the old San Francisco Gas Co. burned 5.8, 5.5 ft. per hour for the same light. A short time afterwards, when our burners were adjusted, the Equitable Co. made as good a light with little more than one-half the amount of gas above named.

Mr. Jones' "Scientific" (?) Tests.

(Our correspondent under this head presents a long and detailed statement, the gist of which may be summed up as follows:

The President and Vice-President of the Equitable Co. were invited to witness a public exhibition of the gas made by the two companies at the laboratory on Stockton St., referred to by Mr. Jones in his letter. They accepted the invitation and were present at the time set; but publicly protested against the tests as unfair and unjust to the Equitable gas for various reasons, as follows: They alleged, first, that the governor on the Equitable gas meter was removed, and their request that it be replaced was refused; second, that the burners proposed to be used in a calorimeter test and in a gas stove were so altered as to be wholly unsuited to the Equitable gas; third, that in a proposed photometer test the instrument being a Bunsen and the standard used a sperm candle, no fair comparison is possible because of the difference in color of the candle flame and the Welsbach light. In view of these protests, according to our correspondent, the only test actually carried out was an examination of the light produced by each of the two gases, and those present were invited to judge for themselves as to the brilliancy of the two lights. Concerning this test, our correspondent's letter says:

Mr. Jones showed a very good incandescent light with the San Francisco Electric Co.'s gas. He gave notice that he would show a light made from the Equitable Co.'s gas. After a little delay, there appeared instead of a bright Welsbach light, a miserable yellow, green and black streak, which did not deserve the name of a light at all, and which, Mr. Jones said, "would require a match to find it.."

Dr. Chisholm replied:

Mr. Mayor and Gentlemen—I confess that Mr. Jones has really performed a miracle with the Equitable Co.'s gas. Everyone present here, and multitudes of the people of San Francisco, have seen thousands of the Equitable Co.'s lights, burning in the best stores in the city, and admired them as the brightest and finest lights ever seen in San Francisco. But when the Equitable gas comes to be manipulated by the San Francisco Gas & Electric Co. it no longer gives a light, but an abortion, which would indeed have to be searched for with a lighted match. Gentlemen, I say to you, Mr. Jones has proved too much. He and his associates have forgotten altogether that there are three bright lights of the Equitable Co.'s gas now burning, right above our heads, in this room. There they are; look at them; bright and clear, and such a contrast to the strangled sample that Mr. Jones has just exhibited.

As to the alleged desertion of the Equitable gas investors by Dr. Chisholm, Mr. Jones' letter continues, as follows:

At this point the men who had brought the process to San Francisco departed for new fields, leaving this dilapidated plant on the hands of the investors in San Francisco.

I say to Mr. Jones, that there are no "men" who have brought the process to San Francisco. One man brought it there, and that one was Dr. Chisholm. He is responsible for it, and he is proud of it.

I left San Francisco the last week of August, to visit a number of Eastern cities, for the purpose of hurrying on material and machinery, to complete the new Equitable gas works at Oakland. I have been a sufferer from rheumatism for over 30 years, and while still two days' journey from Chicago, and while on the train coming East, I had the severest attack of sciatica I ever suffered from in my life. After two days in Chicago, I was taken from the hotel to the Presbyterian Hospital, where I lay confined in bed for over seven weeks. From there I was taken to the Sprague Hot Air Institute, in Chicago, where I remained some weeks longer. I then came on from Chicago to various cities I had to visit, by slow stages to New York, have been under treatment here for rheumatism, and have been in such condition that, even had I been able, it would have been a great risk to attempt a journey across the continent. I will start on my return to San Francisco to-morrow, and expect to reach there by Feb. 5, unless delayed en route by another attack of rheumatism.

The New Company's Business.—Referring to paragraph 13, in Mr. Jones' letter, the "small business" he mentions has been increasing at the rate of about 1,000,000 cu. ft. per month, until the quantity of gas delivered to customers during December by the Equitable Co., and paid for, was about 12,000,000 cu. ft. This business is the result of only a few months' actual business of distributing gas, the previous work having been, in a large measure, preparatory, and that in a new and unexplored field for every man connected with it; but the "business of the Equitable Co. in San Francisco" can be increased just as quickly as its directors desire. They can have it all.

Never in the history of a new gas enterprise was so much done in so little time. From its first demonstration, the gas was a success, both for light and fuel. It has been put into the wrong clothes sometimes, thereby misfitting and cramping it, but that part is only a question of experience and a little time.

I am credibly informed "that it took eight years for the Pacific Gas Improvement Co., of San Francisco, to get on a dividend-paying basis, although it had not to work on entirely new problems (as the Equitable Co. has had to do), but, on the contrary, the experience of generations of old methods were behind them, as well as the valuable aid and direction of the gas experts and gas engineers of the great United Gas Improvement Co.

65-ct. Gas for San Francisco.—The reasons for making the price of gas 65 cts. per 1,000 cu. ft. to the people of San Francisco are no secret. They were published fully in the daily newspapers, when that great boon was announced. All the Equitable's contracts call for $1 per 1,000 cu. ft., for a period of five years, and it was a novel sensation to the much oppressed and heavily burdened gas consumers of San Francisco to have such a benefit voluntarily bestowed. The new gas company is "liberal" as well as "Equitable."

The reasons for this action, as published, are quoted below:

When Mr. Chisholm, who owns the right to manufacture the new gas, came here a little more than 12 months ago, to inaugurate his enterprise, for supplying gas for fuel, heat, light and power purposes, it was with the idea of doing so at as little above 50 cts. per 1,000 cu. ft. as the greater cost of coal and oil compared with those articles in this State would permit. After consultation with his associates and in view of the fact that coal is about $7 a ton, and the oils of the coast were a kind which had never been used for his process, it was decided that it would be well to fix the rate at $1 temporarily, until the process could be thoroughly developed and tested, the cost practically ascertained, and its value for light and fuel made known by actual use.

This has been done—exhaustive experiments made to ascertain the cost of the gas, showed it to be considerably lower than Dr. Chisholm had stated it to be, and the Equitable Gas Light Co. accordingly came to the conclusion that the time had arrived to give the public the full benefit of the great discovery in the manufacture of gas, which this process represents. 65 cts. places the Equitable gas far beyond competition. Used for fuel, it will cut the cost of the coal bill in half. (San Francisco "Chronicle," June 3, 1899.)

The result with the Equitable Co.'s methods, and gas, are: That the business is growing as rapidly as the company is able to take care of it, and that "wherever they put their mains, they get from 75 to 95% of the business at once;" that "they have kept good faith with their customers"; that "the methods of the company disarm criticism", the "the customers are satisfied with the quality of their light," pleased with the smallness of their bills, and that the outcome is "a complete refutation of doubts and discouragements and skepticism"; that the company is "exciting not only surprise but admiration at what has already been accomplished," and "it is remarkable that the only complaint about the gas comes from those who are interested in the old-time companies, and not those who are using it." (These are all quotations.)

Thanking you for your courtesy,

J. W. Chisholm,
Equitable Gas Light Co.
516 California St., San Francisco, Cal.

New York, Jan. 27, 1900.

(We have given much space to Dr. Chisholm to present in his own way his defence of his process. We hardly need say that we do not share his fine scorn for "scientific tests;" and must still insist that until he gives some definite facts and figures from independent and reliable authorities concerning his gas, and his process, both municipalities and investors should regard them with suspicion.

He contends that the analysis of his gas is absolutely unimportant. We contend that it is a matter of vital importance to the validity of his claims; and there is no reason on earth why he should not furnish it. Surely he has such analyses, or else his knowledge of his own process and its results must be limited indeed.

We freely admit that it is entirely possible to make and distribute a fuel gas of moderate calorific power, at a very low cost, and that such gas can be made to give excellent results in Welsbach burners, gas stoves and gas engines. Such a gas can be made, moreover, by well-known and familiar processes, which obtain in the gas from 60% to 80% of the total heating power in the fuels from which it is made, and which operate without any electrical hocus-pocus or mystery whatever. It is not possible to do much better than this with any gas-making process that can ever be devised, for there must always be some loss of heat from the generator, etc., and it is no more possible to create something from nothing or multiply power (or heat, which is convertible to power), in gas manufacture than in any other industry. Perpetual motion is a delusion here, just as truly as in any other department of science.

So far as we can see, Dr. Chisholm has, from his own account, done nothing in gas manufacture in San Francisco that cannot be duplicated with ordinary and well-known gas-making apparatus. Until he presents evidence that his alleged "thermo-electric battery" has some effect that heat alone would not produce, he should not expect any one to take his claims for it seriously.

As for the "practical results," on which he lays such stress, we cheerfully accept his measure of them, viz.: "raising a given quantity of water from a stated temperature to boiling point." When this is done with proper precautions to avoid error, we have one of the "scientific tests," which Dr. Chisholm so much decries. He or any other honest applicant for a fuel gas franchise in a city should be willing to guarantee the calorific power of their gas, so that the consumers may know what they are to receive for their money. Indeed, this should be (although it is not) a stipulation in every franchise for gas distribution given by a municipality. As, Dr Chisholm himself shows, there is a vast difference in the quality of gas. Fifty-cent gas with 300 heat units per cu. ft. calorific power is no cheaper for the consumer than dollar gas of twice the heating power in a given bulk. This may be "science," but it is also common sense.

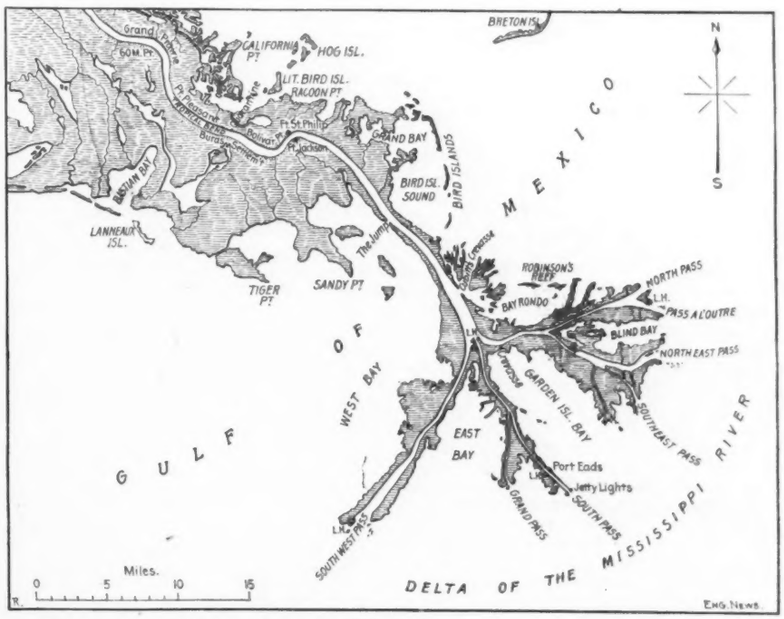
It is entirely true (and is far from being original with Dr. Chisholm) that the incandescent burner is likely to give a great impetus to the use of fuel gas. It is also true that the increasing cost of the oils used for enriching carburetted water gas will tend to cause the gradual abandonment of that process. There is, therefore, an opportunity for success in the manufacture and distribution of a cheap fuel gas, notwithstanding the universal record of failure which has attended enterprises of this class in the past.

We have no desire to discourage any legitimate enterprise of this sort; and our previous and present criticisms are directed, not against the enterprise from this point of view, but against the extravagant and unsupported claims which were made by Dr. Chisholm for his process and its product.—Ed.)

PROPOSED IMPROVEMENTS OF THE SOUTHWEST PASS AT THE MOUTH OF THE MISSISSIPPI.

From what appears to be a reprint of the official report of the board of engineers, contained in the New Orleans "Picayune," the following brief sketch is given of the proposed improvement of Southwest Pass, at the mouth of the Mississippi River.

This board was appointed to report upon a project for obtaining a navigable depth of 35 ft. at mean low water through the Southwest Pass of the Mississippi River, and to submit plans and estimates of cost. The board, as appointed on March 15, 1899, consisted of Col. Henry M. Robert and Lieut.-Col. G. McC. Derby, both of the Corps of Engineers, U. S. A., and Messrs. Robert Moore and William Starling, Members Am. Soc. C. E.



MAP OF THE OUTLETS OF THE MISSISSIPPI RIVER.

This Southwest Pass is one of the three main outlets of the Mississippi, the two others being the Pass-a-Loutre and the central South Pass; the latter was improved by Mr. James B. Eads, under the Act of March 3, 1875. The Southwest Pass is 15 miles long between its head and the Gulf; while the other two passes are about 13 miles long each; from East Point its Gulf terminus to the outer crest of the bar is 4 miles. The width of the Southwest Pass is 2,650 ft. at the head; and it then narrows to 1,450 ft., 2.4 miles down the pass and holds this width for 6.66 miles more; in the lower 6 miles the pass gradually widens until it is 3,000 ft. wide at East Point. The entrance to this pass at the head is obstructed by a shoal, nearly one mile long, on which the depth is 31 ft.; but there is a practicable channel near the east shore with 35 ft. of water. From this point, for 13 miles, there is a channel of not less than 46 ft., with long reaches of 70 ft., and sometimes 100 ft. Beyond the 13th mile the channel shoals to 35 ft., and to 30 ft. at the end of the 14th mile. It then shoals to 28 ft. in the next mile, and after passing East Point there is one mile of channel of about 35 ft.; but the channel then shoals rapidly until at the 19th mile, on the crest of the bar, the depth is only 10 ft. After passing the crest the water deepens, and at 1,500 ft. beyond the crest there is 50 ft. of water.

The sediment brought down by the river is continually pushing out the crest of the bar; and in the 60 years preceding 1898, the average advance towards the Gulf was found to be 259 ft. per year. For the 24 years preceding 1898, however, this advance averaged only 176 ft. per year. The velocity of current in this pass varies with the tide and river stage, from nearly zero to more than 5 ft. per second; and in like manner the volume of discharge varies from less than 40,000 cu. ft. per second to more than ten times that amount. Across the bar the maximum velocity is 4 ft. per second. The banks of the pass are of mud deposited by the river, and slowly consolidated by their own weight, but still easily moved. Owing to its proximity to the mouth of the river, the flood heights are slight, and the banks are consequently so low that at high tide and high river combined the water overflows the banks for nearly their whole length. These banks are also weak and little is required to produce a crevasse.

There are now two notable crevasses at the mouth of the river. Cubitt's gap, on the east bank, 4 miles above the head of the passes, was formed in 1862, and originated in a short cut dug for fishing boats. It rapidly enlarged, until in 1898, it was 3,240 ft. wide, had a maximum depth of 72 ft., and carried 155,000 cu. ft. per second, or nearly half the volume of the Southwest Pass. The other crevasse is on the west bank of Pass-a-Loutre, two miles below its head. This break dates from 1891, and was only 15 ft. wide and 14 ft. deep when first discovered. It grew rapidly, and now, after three ineffectual attempts to close it, it carries 38% of the water entering this pass. There are several openings in the banks of the Southwest Pass; the largest is Lighthouse Bayou, 240 ft. wide and 10 ft. deep. The waters of the river cannot be de-

pended upon to maintain a channel in Southwest Pass unless these crevasses are controlled; and the board recommends that Cubitt's Gap, the crevasse in Pass-a-Loutre, The Jump and other openings now existing be prevented from enlarging by laying a substantial mattress-sill across the larger ones, and closing the smaller outlets entirely.

The channel proposed by the board in Southwest Pass would be not less than 1,000 ft. wide and 35 ft. deep. There is in the pass now, for 12.6 miles, a chanel of these dimensions, with the following exceptions: A section 1½ miles long where the 35-ft. channel is only from 800 to 900 ft. wide, but with a greatest depth of 75 to 100 ft.; and a few places where the channel is narrowed by short local shoals, easily removed by a few days' dredging.

To form a channel across the bar the board does not propose to use the ordinary method of restricting the width by training walls in order to increase the velocity of the current, scour out the bar, and carry the materials to sea. This is the method usually relied upon, but the board deems this plan dangerous. Contraction works at the mouth of the pass would increase the resistance to flow, diminish the flow through the pass, and sediment would be deposited in the pass itself in enormous quantity. This action actually took place at South Pass, during the construction of the jetties. Consequently, the present board is clearly of the opinion that great care should be taken to avoid any material decrease in the flow through the pass, and that it is better to depend mainly upon dredging for forming the new channel. With the new channel once opened, however, suitable works may be safely built to assist the current in maintaining the channel. Dredging can now be done for 2½ to 4 cts. per cubic yard, instead of 25 cts., the cost a few years ago; but to obtain 35 ft. it would be advisable to dredge 38 ft.; and with 38 ft. depth and a channel 1,000 ft. wide, with side slopes of 1 on 10, the aggregate of 22,000,000 cu. yds. would cover the dredging to be done between deep water at the head of the pass and in the Gulf. If two-thirds of this total be removed by dredging the balance might safely be removed by the scour of the river. The board estimates that two dredges of the type of the largest now used on the Mississippi River would do this work in two or three years of actual dredging, at a cost not exceeding 4 cts. per cu. yd.

To preserve and maintain the channels the board proposes two lines of jetties, extending from East Point out to the 20 ft. contour on the outer slope of the bar. The line of these jetties assumes the form of a bottle, with a width of 7,000 ft. as a maximum, and 3,000 ft. as a minimum. This seemingly excessive width across the bar is adopted by the board for the following reasons: The channel is to be dredged, and the contraction produced by the jetties is not depended upon for this work. An economy in first cost is secured by placing the jetties in shallower water; the greater area enclosed affords a more convenient dumping ground for the dredged material, and this material will assist the river to carry on more rapidly the natural process of forming its permanent banks, in which the inner parts of the jetties will ultimately be buried, as at South Pass. The shoals on both sides of the jetties help to break the force of the waves and also protect them from being undermined by the river current. With this accumulation of deposits on the inner sides of the jetties the board has not deemed it necessary to build them to such a height as to prevent storm waves from passing over them; they have limited the height of these jetties to that of mean high tide, and thus largely reduce the cost.

In building these jetties the board proposes to first lay a flexible foundation mat, not less than 2 ft. thick, nor more than 150 ft. wide. About 70 lbs. of stone per square foot of surface will sink and hold this mat in place; and the mat itself will protect the jetties from being undermined by the river current or wave action. It will also assist to distribute the weight of the jetties proper. This mat would be laid throughout the entire length of the jetties and 1,000 ft. beyond before any work is done on the superstructure; and the outer 4,500 ft. of the foundation mat would be 200 ft. wide.

The character of the superstructure will vary with the depth of water. For the East jetty, out to a depth not exceeding 3 ft., all that will be required will be another mat weighted with stone. In water deeper than 3 ft. there should be a superstructure of concrete, laid in large blocks, as being more effective against wave shock than random stone. Concrete also permits the use of sand, gravel and shell which are here abundant and cheap, while suitable stone for rubble work is comparatively expensive. To distribute the weight of the concrete, a timber grillage, of not less than two courses, will be employed. The lower course will be laid lengthwise of the jetty with the second crossing at right angles. The width of this grillage should be such as not to impose a load greater than 300 lbs. to the square foot of grillage-base. With this limiting load of 300 lbs. the board estimates that the structure would not settle more than 4½ ft., causing the mattress and 2 ft. of grillage to be covered with mud. Consequently, the board does not think it is necessary to creosote this lower 2 ft. of grillage; but, to protect the timber against the toredo, all the rest of the grillage should be creosoted. The concrete may be laid in large bags; or, it may be made of blocks built up on shore and laid with derricks. The board recommends laying blocks of the full cross section of the jetty; and for purposes of estimate it assumes a top width not exceeding 9 ft.; side slopes, 2 on 1, and the depth of the block 4½ ft. more than the depth of water at mean-high tide—less the 2½ ft. thickness of the mat and the depth of grillage necessary to reduce the distributed weight to the prescribed limit.

It is proposed to suspend the grillage, in suitable lengths, between two barges; erect upon it forms for the concrete, and fill these forms and allow sufficient time for the concrete to set; the whole would then be towed into position and sunk by allowing water to enter the barges. By this system the concrete would be made into blocks in quiet water. As the West jetty will be much less exposed to wave action, the board is of the opinion that the width of crown may be safely made one-third less than that finally adopted for the East jetty. The estimates provide for jetty-heads made of large cylindrical blocks of concrete; and also for special protection at deep-water points, by double lines of blocks. The board does not believe that the inner jetty—referred to in the Act of March 3, 1899, will be required.

In the following estimate of cost the closing of the Pass-a-Loutre crevasse is not included, as Congress has already provided for this work. The estimate submitted is as follows:

Dredge	$350,000
Mattress sill, 300 ft. wide across Cubitt's gap	170,000
Mattress sill across the Jump	23,000
Mattress sill across Baptiste Collet's canal	10,000
Closing all minor outlets below the forts	33,000
Dredging 22,000,000 cu. yds. at 4 cts.	880,000
Foundation mat, 6,500,000 sq. ft. at 15 cts.	975,000
Rip-rap, 60,000 cu. yds. at $3.	180,000
Grillage, 20,000 M. ft of yellow pine at $25	500,000
Creosoted grillage, 1,400 M. ft. at $55 per M	77,000
Concrete, 100,000 cu. yds. at $7.50	730,000
Jetty heads and protection of outer ends	200,000
Plant, tugboats, barges, tracks, buildings, land, etc.	400,000
Contingencies and administration, about 32 per cent.	1,448,000
Total	$6,000,000

The percentage for contingencies in the above estimates is unusually large, but it is to be borne in mind that the work is one more than ordinarily liable to special difficulties, which do not admit of calculation, such as the effects of storms, unfavorable foundations, and uncertain action of the river currents. If no serious unforeseen difficulties are met with and the funds are supplied in sufficient quantity a practicable ship channel through Southwest pass should be open to commerce at the end of three years from the time when the funds become available, and the entire work should be completed in five years. It is assumed that the whole amount of the estimate will be appropriated in four equal annual appropriations.

NEW VALVE GEAR FOR STEAM ENGINES.

The new style of valve gear which we illustrate this week possesses some features of particular interest, and is reported as giving very satisfactory results on marine and stationary engines to which it has been applied. It is a radial gear, with a single eccentric for both forward and reverse movements, motion being taken from points 180° apart on the eccentric strap. Fig. 1 represents the gear as adapted to marine engines. On the main shaft is keyed an eccentric, the strap of which is fitted with pins (A) and (B). Above the shaft is the horizontal curved link (C), one end of which is attached to a rod (D) of adjustable length, which rod is attached to the pin (B) of the eccentric strap. Above the bed is a fixed shaft (E) supported by standards or by brackets cast upon the engine columns. Upon this shaft are journaled a pair of triangular levers (F), with bearings for pin (A) in the eccentric strap and for trunnions (G) on the sides of the link, upon which trunnions the link rocks. The valve rod or radius rod (H) is attached to the link block (J) by the pin (I), and is shifted to any desired point along the link by means of the bridle rod (K) attached to the end of the reversing lever (L). The pin (M) is simply a spacing pin, at the end of the bars forming the link. When in forward gear, the eccentric is 112° behind the crank pin, and in backward gear it is 112° ahead of the pin.

As the bearing at (E) is a fixed point, one effect of the revolution of the eccentric is to give the link a vertical reciprocating movement, the

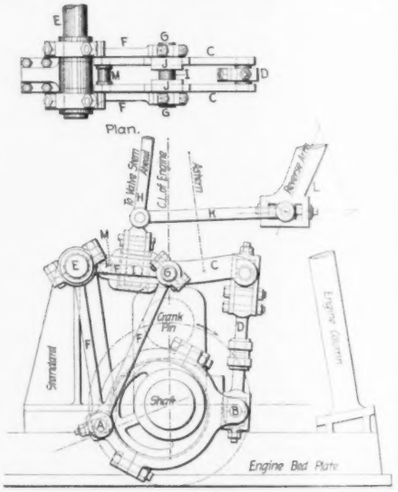


Fig. 1.—The Lang Valve Gear as Applied to Marine Engines.
Lincoln A. Lang, Inventor.

amount of this movement being equal to twice the sum of the lap and lead. As pin (A) travels through a non-variable path or arc, by reason of its connection with the triangular lever, the pin (B) is caused to travel through an ellipse whose major axis is parallel with the center line of the engine. This movement being transmitted by the rod (D) causes the link (C) to oscillate on its trunnions, in addition to its reciprocating motion imparted by the triangular lever. Thus the link has no fixed fulcrum. When the rod (H) is set in the center line of the engine, the valves will open the ports only to the amount of the lead, but as it is shifted to either side, the port opening becomes larger and the point of cut-off later.

The link is much shorter than usual, and the throw of the eccentric is but about two-thirds that required where the Stephenson link motion is used. The eccentric is advanced somewhat ahead of pin (A). In an engine of 42 ins. stroke, cutting off at three-quarters of the stroke, the distance between the center lines of the link block in forward and backward gear need not be more than 18 to 20 ins. The triangular levers and the link (the latter having (G) as its fulcrum) form a system of compound levers by means of which unbalanced valves can be easily handled, while the wear is concentrated at (E), which can be given ample bearing surface and can be readily adjusted. The single eccentric used is of course less of an obstruction than the double eccentrics ordinarily used, and as the link is placed close to the main

shaft it does not interfere with access to the guides and crosshead when the engine is running. With an attachment at both sides, the wear is distributed around the circumference of the eccentric strap. With this gear, also, the ports may be made narrower, so that engines specially designed for its use may have a very small percentage of clearance. In a marine engine the clearance may be reduced to 5%. The advantages claimed for this gear may be summarized as follows: Constant lead; rapid opening and closing of ports; large port openings with short cut-off; long exhaust period; wide range of expansion; equalization of cut-off points throughout this range; sensitiveness to movement of reversing lever or governor; freedom from vibration; and economy in fuel consumption owing to the economical use of the steam.

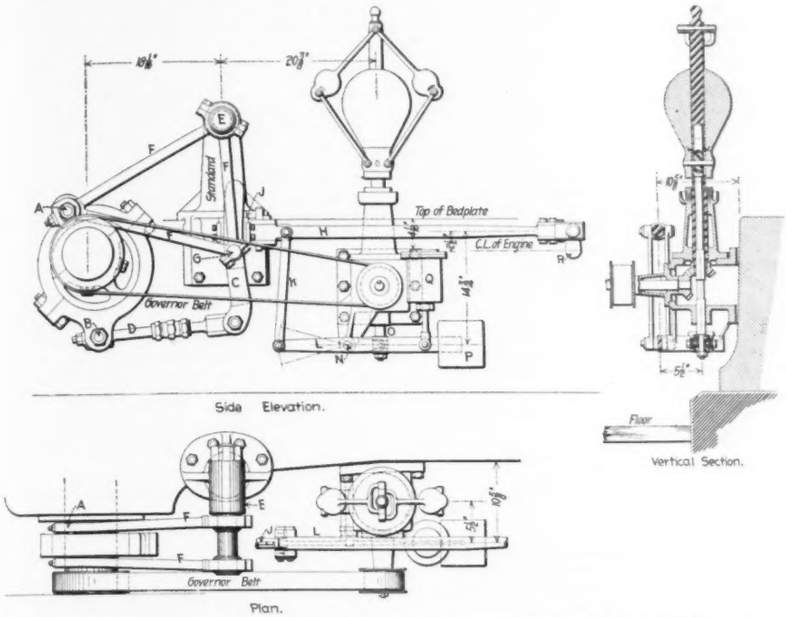


FIG. 2.—THE LANG VALVE GEAR AS APPLIED TO A PUMPING ENGINE AT THE WEST SUPERIOR (WIS.) DRY DOCK.

This valve gear has been applied to two tug boats and one ferryboat on the Great Lakes; to one of the horizontal pumping engines at the Dry Dock at West Superior, Wis. (where it is used as an automatic cut-off); and to a double cylinder hoisting engine at the mine of the Oliver Iron Mining Co., at Iron River, Mich. This engine has cylinders 12 × 16 ins., and the gears were manufactured by the Parish Manufacturing Co., of Ashland, Wis. The valve gear is now being fitted to the compound engine for a steam yacht being built for Mr. Robert Kelly, of West Superior, Wis. The cylinders are 5 × 10 × 8 ins., and the boiler pressure will be 200 lbs. One of the tugs above mentioned has a cylinder 18 × 22 ins., working under a boiler pressure of 120 lbs., and with the Stevenson valve gear, working at 75% cut-off, the engine made 180 revolutions per minute. With the Lang valve gear it was found that the engine would make 100 revolutions per minute under a cut-off shortened to 20%, the engine being then able to handle a considerable tow with a very slight consumption of fuel. Plans have also been prepared by a western railway for the application of the gear to a locomotive, but under present traffic conditions the road has not yet been able to spare an engine for experimental work. The gear can also be adapted to Corliss valves, using two radius rods, one driving the admission valves by a wrist plate, and the other driving the exhaust valves.

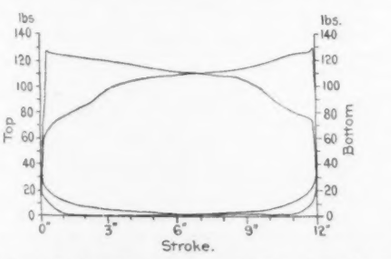


Fig. 3.—Indicator Diagram from Engine of Tugboat "Islay" Fitted with the Lang Valve Gear.

Cylinder, 10-in. diameter, 12-in. stroke; clearance, ¾-in.; boiler pressure, 140 lbs.; valve gear, in position for backing; speed, 190 revolutions per minute.

Fig. 2 shows the gear as attached to the dry dock pumping engine, and connected up to the governor instead of to a reversing lever. This engine has cylinders 18 × 22 ins., cutting off at 50% of the stroke, and drives centrifugal pumps at a speed of 400 revolutions per minute. The lettering of the gear is the same as on Fig. 1. The lever (L) has its fulcrum on pin (N), in the governor casting, while its end is connected to the governor stem at (O). An extension of the lever carries the counterweight (P), which adjusts the pull of the governor; and is attached to the dash pot (Q), which steadies the motion and prevents fluctuation or "hunting" of the governor. Any slight rise or fall of the governor balls at once shifts the link block and valves. As the engine is not reversible, the link is slotted at one end only, but the slot is extended just below the center line, so as to allow the block to go slightly into back gear if the speed should raise the governor abnormally high. If the governor belt should break, the weight of the link block (J) will overcome that of the balance (P), so that the block will fall and the engine will be stopped. The connection between the radius rod (H) and the valve stem, at (R), is raised above the center line of the engine, in order that the rod will normally remain horizontal. The triangular levers (F) have their short, or link-supporting, arms, made longer than usual, on account of the engine being fitted with gridiron valves, which require a very long lap and lead motion with comparatively short port opening movement. The link is also made short to secure a reduced lift of the governor.

Fig. 3 represents an indicator diagram taken from the engine of the steam tug "Islay," fitted with the Lang valve gear. The engine has a single cylinder 10 × 12 ins., with ¾-in. clearance, and the diagram was taken when the engine was running at 190 revolutions per minute, with a boiler pressure of 140 lbs.

The valve gear here described is the invention of Mr. Lincoln A. Lang, of Yule, N. Dak., who is President of the Lang Radial Valve Gear Co., Endicott Arcade, St. Paul, Minn. The detail drawings and the actual gears have been made by the Superior Shipbuilding Co., of Superior, Wis. We are indebted to Mr. Lang for blue prints and information respecting this device, and are informed that steps are being taken to introduce it in Europe.

A STATE EXAMINER OF STEAM ENGINEERS is the subject of a bill now before the New York Legislature. He would receive $3,500 salary and hold office for 5½ years under appointment by the governor; he may appoint not more than 18 local examiners. After the passage of this act everyone serving as an engineer, or in charge of a steam boiler—excepting locomotive engineers or those holding licenses from the U. S. Supervising Inspectors, must be examined and obtain a certificate of fitness from the examiner or his assistants. The license fee would be $2.

A DEPARTMENT OF MINES AND MINING in the national government is proposed in a bill recommended by the House Committee on Mines and Mining. The secretary at the head of this department would rank with other cabinet officers and have entire charge of all affairs relating to mines and mining, including the U. S. Geological Survey. Another bill, favorably acted upon at the same time, would establish mining experiment stations in each of the mining states, and would appoint government geologists, at $3,500 per year, and assayers, at $2,500 per year, in the mining states.

THE ENTRANCE TO THE WELLAND CANAL, at Port Colborne, on Lake Erie, is to be improved by the building of two new docks, each 600 by 200 ft.; by dredging to 22 ft. in front of these docks, and the entire basin and entrance to the canal is to be deepened to 15 to 16 ft. over a length of about 4,000 ft. Westward of this dredged area, it is proposed to build a breakwater 7,500 ft. long. Work upon the deepening is to begin in the coming spring, and the breakwater must be completed before June 30, 1902.

A TELEGRAPH CABLE TO ICELAND is projected, says Mr. V. E. Nelson, U. S. Consul at Bergen. The distance from the Shetlands to Iceland is 404 miles, and a Danish company offers to lay the cable for $1,407,000, but another company bids $850,000 for a cable between Iceland and the Orkney Islands—a greater distance than to the Shetlands. The trouble is that the Icelanders, who have little use for it, are too poor to pay for such a cable, and the nations really benefited will not pay for it.

AN EXPERIMENTAL GARBAGE REDUCTION plant has been built at 26th St. and Archer Ave., Chicago. The system employed is said to be the invention of Mr. Chas. Turner, General Manager of the Chicago Reduction Co., 2635 Archer Ave., Chicago. Mr. Turner informs us that he prefers to give no information regarding the system for publication. Dr. Arthur R. Reynolds, Commissioner of Health of Chicago, informs us that there is no contract relation between the company named and the city, but that some of the scavengers who collect garbage from hotels and other places for pay find it convenient to take their garbage to this plant.

A UNIVERSAL METER SYSTEM FOR JERSEY CITY has been recommended by Mr. Chas. Van Keuren, Chief Engineer of the Board of Street and Water Commissioners. Acting under the instructions of the board Mr. Van Keuren estimated that 25,800 meters, sufficient for all unmetered services, could be bought for $475,000 and set for $100,000, including all fittings. By this means he believes the consumption could be reduced one-third and the net revenue greatly increased. The meter rates proposed are 25 cts. per 1,000 gallons up to 10,000 gallons a quarter, diminishing to 10 cts. per 1,000 gallons for all water used above 60,000,000 gallons a quarter. The meter question has been forced upon the city by the fact that it is buying its whole supply from the East Jersey Water Co. by meter measurement and selling the bulk of it at fixture rates. Thus the city must pay for every drop at one end of the supply while the consumers, at the other end, waste as much as they choose without suffering for it. This state of affairs is partly responsible for $285,000 of arrearages, due the East Jersey Water Co. by the city. Mr. Van Keuren says the average daily consumption is 31,000,000 gallons, of which he debits 1,000,000 gallons to public purposes. The records show that about 10,000,000 gallons a day is sold by meter measurement and the balance at fixture rates. The total annual revenue of the water department is $907,633, of which $25,000 is for permits, leaving $882,633 for the water itself. Of this, $374,898 is for metered and $507,735 for unmetered water. In other words, 33% of the water supplied brings in 43% of the revenues. Doubtless the metered consumers are nearly all paying what may be termed wholesale rates for their water, which makes the discrepancy between metered and unmetered consumers still greater. It should be noted, however, that the 20,000,000 gallons of unmetered water includes street main leakage.

MUNICIPAL ELECTRIC TRAMWAYS IN ENGLAND.*

Without attempting to raise the principle of municipal ownership of tramways and similar undertakings, we may draw attention to the fact that, of the 50 electrically-operated systems which are in active existence at the present moment, no fewer than 24 are being worked or are being constructed by municipalities. These undertakings include such schemes as that of Manchester, which, though under construction, is a good way from completion. Undoubtedly the most important scheme in this country is this of Manchester, for which the enormous sum of £860,000 ($4,188,000) has been voted by the corporation. The most active body in this country as regards electric tramways is the British Electric Traction Co., and, despite the fact that this organization is operating and arranging for numerous lines in many parts of the country, its capital is not much greater than the amount of money which it is proposed to expend in Manchester. In many cases municipalities have taken up electrically-operated lines in a tentative fashion; on the other hand, we see a town like Salford, without any special experience, undertaking the construction of some 40 miles of single track. Although local authorities are somewhat deeply pledged in electric tramway enterprise, the extent of mileage of lines is not especially great at the moment. One of the largest systems in actual operation at the present time is that of the Blackpool Corporation, which is operating some 11 miles of single track. The Bradford Corporation has 5 miles in actual working, Blackpool 4 miles, Darwen not 3 miles, the Corporation of Dover 3 miles single and 1½ miles double track. The city of Glasgow is actually working 3¾ miles of double track, the town authorities of Halifax 11¼ miles, Hull 3½ miles of double track, Leeds 7 miles of double track, Liverpool about 7 or 8 miles, Plymouth Corporation 3 miles of single track, St. Helens 6 miles and Sheffield 2 miles single and 9 miles double track. All these lines are in actual operation. It is when we come to consider the proposals for new lines and systems under construction that the significance of the municipal principle is best seen. For instance, the Blackburn local authorities are actually equipping 15 miles of track, the Blackpool authorities are about to extend their track by some 15 miles, the Bolton Corporation is adopting electric tramways to the extent of 31 miles, the Bradford Corporation is constructing three distinct and separate lines, the Glasgow authorities are constructing 35 miles of double track, Leeds projects 36 miles and is actually constructing 22 miles, the Liverpool system when completed will be over 20 miles in length, the Oldham Corporation will shortly be operating 25 miles, St. Helens Corporation is constructing 13 miles and the Sunderland authorities are constructing a system which will be over 23 miles in length. It is too early yet to draw any conclusions as to what type of plant will be mostly affected, but it is distinctly interesting to note that, with probably one exception—Glasgow—the systems will be operated from combined lighting and tramway works.

*Reprinted from the London "Surveyor," for Jan. 12, 1900.

BOOK REVIEWS.

ANALYSE MICROCHIMIQUE ET SPECTROSOPIQUE. Par M. E. Pozzi-Escot, Chemiste, Redacteur au "Practicien Industriel," Membre de la Societe Francaise de Physique. Paris: Gauthier-Villars. Paper; 7⅝ × 4⅝ ins.; pp. 192; illustrated. 2½ francs (75 cts.).

The new form of qualitative chemical analysis here discussed is based upon a study, with the aid of the microscope, of the crystalline form of precipitates, their color and characteristics. The author illustrates and describes the apparatus used, the reagents employed and the method of conducting operations on various classes of chemicals.

THE MODERN SAFETY BICYCLE.—By H. A. Garratt, Assoc. M. Inst. C. E.; Head of the Engineering Department of the Northern Polytechnic Institute, Halloway; formerly Lecturer in Engineering at the University College, Bristol. London and New York: The Macmillan Co., 66 Fifth Ave., N. Y. Cloth; 7 × 5 ins.; pp. 224; illustrated. $1.

If you want to know how your bicycle is made, why it assumes certain forms, and how it operates, purchase this book. Mr. Garratt takes up each separate part of the bicycle and describes it in detail; he shows the variety in design and tells why certain forms are better than others. The subject is treated both from the point of view of the designer and the maker, and no detail of any consequence seems to be omitted. A full index adds largely to the value of the book.

HAND-BOOK OF TESTING MATERIALS.—By Prof. Adolf Martens, Director of the Royal Testing Laboratories at Berlin and at Charlottenburg. Translated by Gus. C. Henning, M. Am. Soc. M. E. Two Vols. Cloth; 6 × 9 ins.; pp. 622 and 240; illustrated. $7.50

The purpose and scope of this book is stated by the author in his preface to the German edition, as follows:

My book on "Testing Materials for the Constructor" is designed to be a counselor to the constructor in all questions relating to the properties of his materials of construction. Therefore the book is divided into two volumes, each independent and complete in itself. This first volume relates to the general properties of materials of construction, and especially to the art and science of testing materials as applied to machinery and superstructure. To the description of the customary methods of testing I have added a presentation and discussion of the most important types of testing machines and auxiliary apparatus, dwelling mainly upon the underlying principles of design, sources of errors and their calibration.

The translator in his preface says:

In spite of the existence of numerous able works on the same subject I do not hesitate to come before English speaking engineers and manufacturers with a translation of Prof. Martens' book, because being familiar with the others, I know that his treats the subject from a point of view so very different that to most, even the experts, the subject will appear like a new one.

The engineer who will read the book carefully will, we think, agree with the translator in his estimate of the novelty and importance of the work. Nothing at least is risked in saying that as a treatise on the technique of testing machine construction and operation and of manipulating the tests of materials it is equalled by nothing in English. The translator's work is on the whole good, the only fault being that in his attempt to get accuracy in fact and statement his text has a somewhat slavish literalness which makes it awkward reading. A stronger criticism which may be justly urged against the book as it appears in English is that all the illustrations are relegated to a separate volume, which, as the figures are very numerous and are being constantly referred to in the text, makes the book a most trying one to read or use. We can see no reason why the cuts could not have been as well printed with the text. The use of wide-spaced Roman type, with no greater spaces between words than between letters, as a substitute for Italics, is another feature which adds to the difficulty of reading the book. These criticisms may seem rather captious, considering the excellence of the book's contents and their careful treatment, but that is the one reason really why they deserve to be frankly stated. Despite them, we can honestly advise any of our readers who may be interested in the subjects of which the book treats to purchase it for their libraries of reference.

REPORT OF THE SUPERINTENDENT OF THE STATE LAND SURVEY OF NEW YORK.—Transmitted to the Legislature March 2, 1896. Senate Document No. 42, by Verplanck Colvin, Superintendent. State Printers, New York and Albany, 1896. Cloth; 9 × 5¾ ins.; pp. 405; maps and half-tone illustrations.

The long delay in the appearance of this report—for it was only published in October, 1899—is accounted for when its contents are examined; and it would have been wise economy to have suppressed it altogether. As an official document it is a curiosity; for while purporting to be a progress report on the state land surveys, there is not a single new statement of fact between its covers, and the only additional surveying information to be found is contained in a few small colored maps, covering a trivial area. These maps are well executed, and would indicate that about 40 sq. miles of territory surveyed represent the total result of about 25 years' work and the expenditure of several hundred thousand dollars. It is interesting to here note that the Co-operative Topographical Survey, under the direction of the State Engineer since 1893, has covered 3,700 sq. miles at a cost of less than $50,000.

The first 100 pages of the report are chiefly devoted to a recital of Mr. Colvin's personal experience in traveling through the "wilds" of the most popular and well traveled portions of the Adirondacks. He encountered "three large tame bears in charge of some French mountaineers," and suddenly came upon "a new brightly painted hay-rake in a meadow"—among other adventures. The next 170 pages are still more remarkable for their detail, for they consist of a copy of the ordinary field note-books used by the surveyors in running the outline of one little township. Ordinarily, these books are filed away and the contents are boiled down into two or three pages of the report. But Mr. Colvin inserts them here as "an illustrated chapter of the amount of work which has to be done to survey this one township." The remainder of the report consists of 70 pages of Acts of the Legislature, and some preliminary pages of the report proper. In fact, about 400 pages of printed text are wasted to describing what was done to survey a total area of 150,000 acres, or about 230 sq. miles; and the only topography published covers 35 sq. miles.

This report does not give a single elevation of the hundreds which should have been determined in running many miles of spirit levels at a great cost; not a single trigonometric position is noted, though mountain tops were cleared, signals erected and angles observed; there is not a line regarding the final position of a single boundary; nor a square mile of general map. But Mr. Colvin says that "conclusions will be given in a future report," as he has promised in all preceding reports; and this expression will probably appear as long as the State Legislature sees fit to provide for a continuation of the survey under its present form. In a note on p. 326 the Superintendent holds out the appalling possibility of unlimited volumes of a similar kind to follow—"for the perfection of the records."

As a book, this report, like its predecessors, is attractive in appearance. It is full of pretty pictures and flowing generalizations, and to the layman it has the appearance of giving much information. It is intended to impress the people of the state and its representatives in the Legislature; but, as here indicated, it gives no information worth the cost of printing, and fails to give any actual results that are available or useful to public officials, or to those interested in engineering, forest or water-supply investigations.

BACTERIA.—Especially as They Are Related to the Economy of Nature, to Industrial Processes and to the Public Health. By George Newman, M. D., F. R. S. (Edin.), Demonstrator of Bacteriology at King's College, London. "The Science Series." New York: G. P. Putnam's Sons. London: John Murray. Cloth; 6 × 9 ins.; pp. xiv., 348; 85 illustrations.

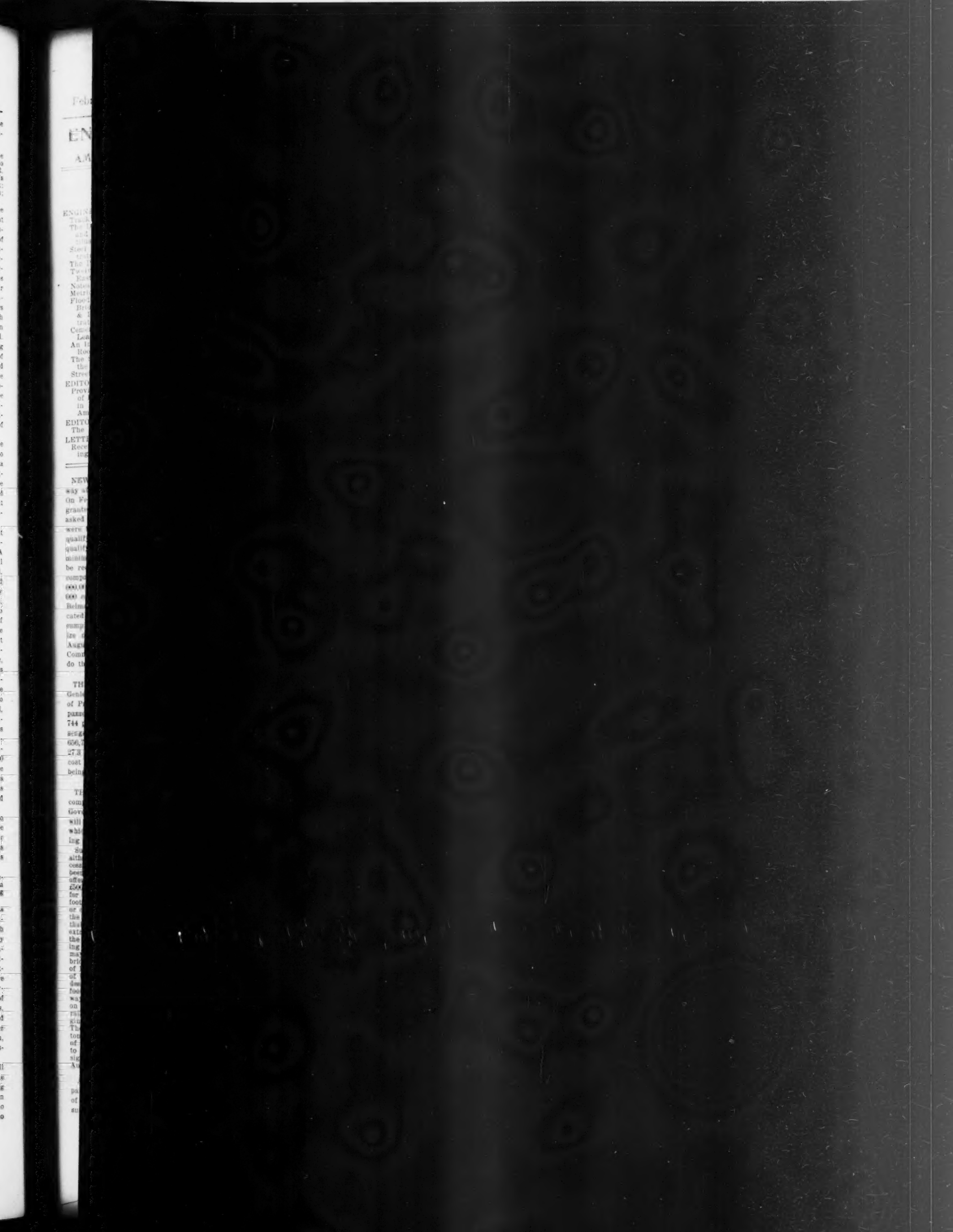
As the author of this book well says, "probably the most universally known fact respecting bacteria is that they are related in some way to the production of disease." If only a few of the great underlying principles of this relationship were as well known, or if they were understood by those officials who are supposed to be responsible for the public health, many of our most widespread and dreaded diseases might be stifled and perhaps stamped out in a few years. Unfortunately this is so far from being the case that even a large proportion of municipal health officers are, in these matters, blind leaders of the blind. This is due largely to the rapidity with which bacteriology has developed and the uncertainties in which some of its many ramifications are still involved. One of the encouraging signs of the times is the growing interest in scientific matters shown by a large number of thinking people, an interest which is partly the cause and partly the effect of such books as are included in the numerous science series now being issued by various publishers in this country and abroad. The present volume is sixth in such a series, now being published as indicated above under the editorship of Prof. J. McKeen Cattell, of Columbia University, with the co-operation of Frank Evers Beddard, F. R. S., in Great Britain.

Aside from the general interest pertaining to the whole subject of bacteriology, the portions of the book likely to be of greatest value to our readers are those on bacteria in water, the air, the soil, milk and other foods. Antitoxins and disinfection are also discussed in an instructive manner. The chapter on "Bacteria and Disease" should prove of great value to any one who desires a clear but reasonably brief summary of the latest ideas on this subject.

It would have been well if the author had made it clearer that at present no reliance can be placed on attempts to isolate specific disease germs from water. A careful reading of all he says bearing on the subject will make this evident to minds that are fairly well trained, but, unfortunately, many people read too hastily and generalize too freely to grasp all that the author really imparts on this subject. We fear, too, that some readers, not already on their guard, may be led by the author to place too much confidence in the natural purification of water once polluted by sewage, more particularly where the water is used for drinking purposes. Some persons might also be misled by the statement that chemical precipitation is a "simple and cheap" method of treating sewage, even though this is qualified by the clause, "but it does not remove the organic matter in solution." As the author is an Englisman, it seems as though he should have been aware that chemical precipitation was never so much in disfavor as at present, especially in England, and that one of its greatest drawbacks is the expense entailed for a partial process of purification which leaves the "sludge problem" unsolved. Occasionally the author does not express himself very clearly, and one sentence has been noted which contradicts itself. On p. 80 it is stated that: "Pure cholera bacillus • • • were passed through these filters and not a single bacillus was detected in the filtrate." The intention, apparently was to say that liquid containing cholera bacilli was passed through the filters, etc.

Most of our adverse criticisms, it will be seen, relate to applied bacteriology on its engineering side. Along the same line we wish to commend most heartily the manner in which the relation between sewer air and bacteria is presented. The author clearly shows that the ill-effects due to sewer air

are in all probability produced by a lowering of the resistance and vitality of the tissues, and not by either a conveyance of bacteria in sewer air or any stimulating effect upon bacteria exercised by sewer air.

This attitude is diametrically opposed to popular ideas on the subject, and those ideas were originally disseminated by the medical profession and by municipal health officers, and, worse yet, are still being spread abroad by the same agencies. Both personal and public health is endangered by this delusion, because isolated cases and epidemics of preventible diseases are constantly being attributed to sewer air or "sewer-gas poisoning," where the real cause is polluted water or milk supply. By saying this we do not mean to belittle the importance of properly constructed city and house sewerage systems, well ventilated and otherwise cared for as they should be, but to call attneiton to the real dangers from sewer air, in order that they may be given proper attention, and at the same time that other hidden foes may not escape.

In conclusion, we gladly commend this book to all health officials, including members of city and state boards of health, to municipal and other engineers having to deal with sanitary problems, and to all interested in bacteria (to quote from the title) "as they are related to the economy of nature, to industrial processes and to the public health"—and who is not?